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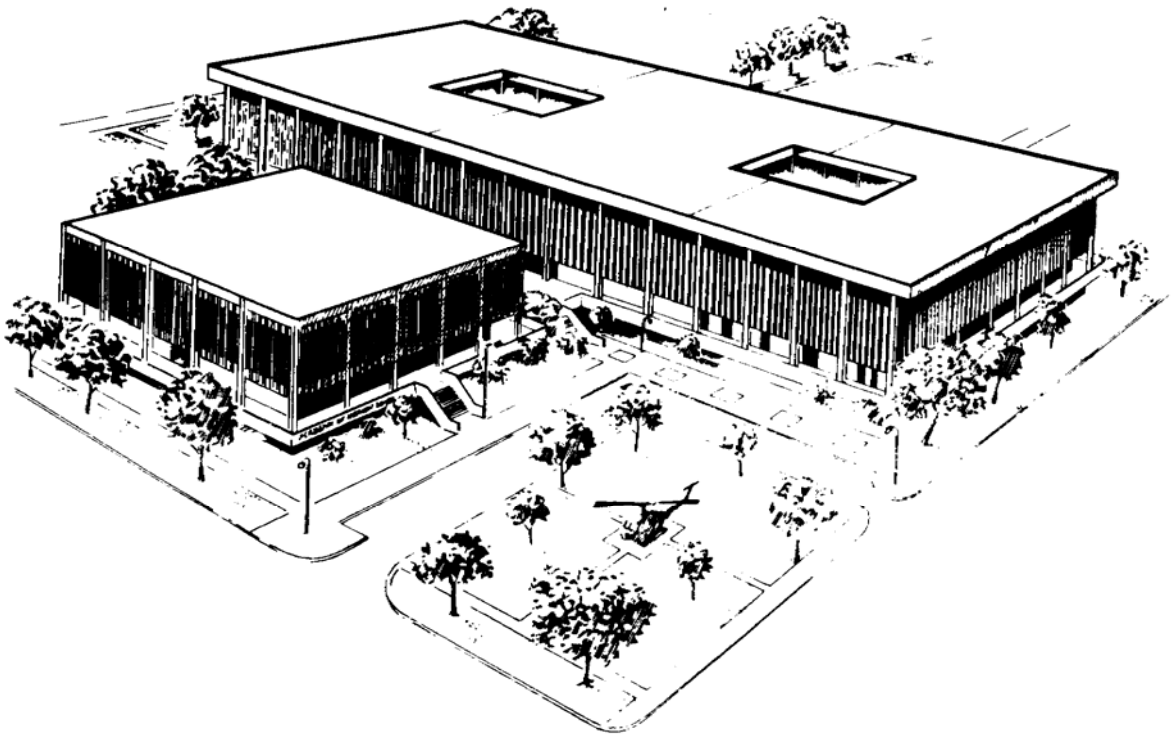
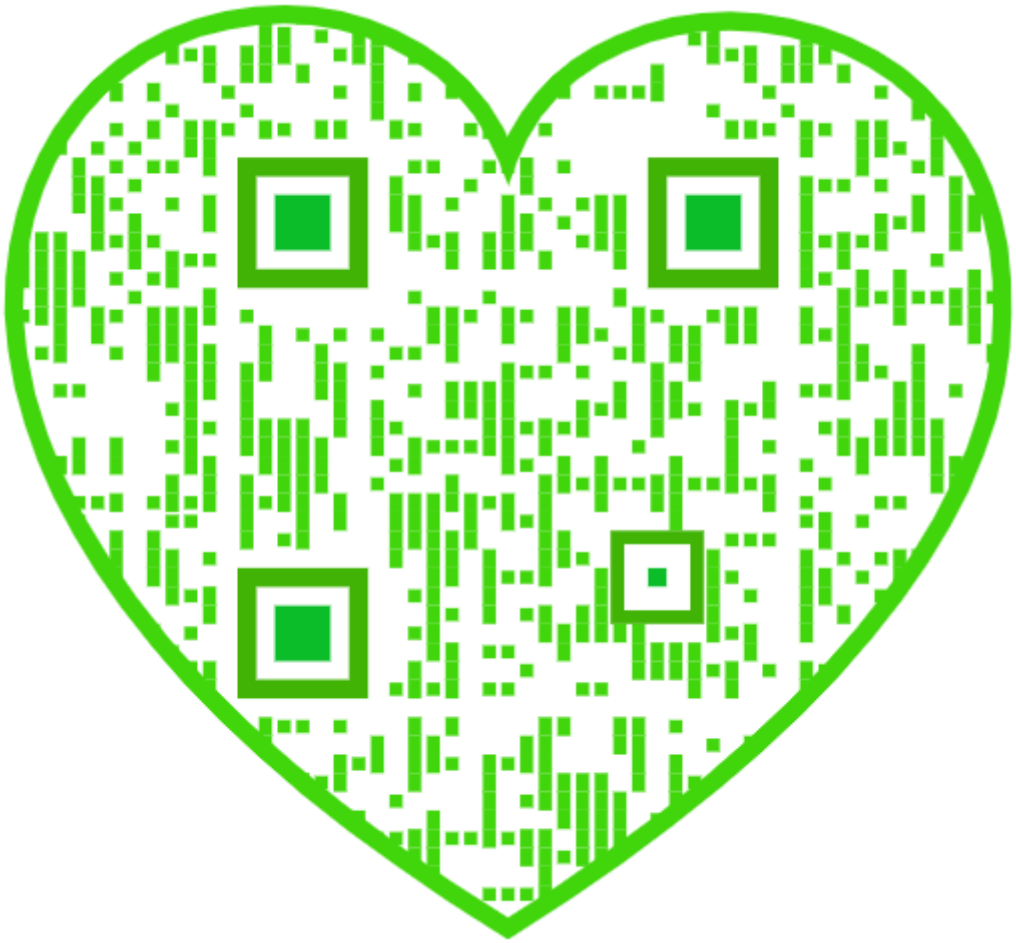


FLUOROSCOPY AND SPECIAL RADIOGRAPHIC TECHNIQUES

SUBCOURSE MD0959 EDITION 200



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CORRESPONDENCE COURSE OF
THE U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL

SUBCOURSE MD0959

FLUOROSCOPY AND SPECIAL RADIOGRAPHIC TECHNIQUES

INTRODUCTION

This subcourse deals with fluoroscopy and with a number of other special techniques and procedures. Some of these are not done often and may require extra study to make up for lack of practice. Whether a procedure is demanding or routine, it is important to remember you are dealing with a person and not just a technique. That person, as well as the doctor, is depending on you to use these techniques in the best way possible to produce radiographic useful in diagnosis. You will also be depended upon as a member of the team in fluoroscopy where the radiologist expects to see an image on the screen that tells him what he needs to know.

You may find it quite useful at this point to review some of the preceding subcourses, especially Subcourse MD0952. The information contained in them is presupposed in this subcourse. If radiographic technique and positioning are still a mystery to you, you may flounder on these basic things and not be able to go forward with the aspects of the material that are new.

Subcourse Components:

The subcourse instructional material consists of four lessons as follows:

Lesson 1, Fluoroscopic and Special Radiographic Equipment.

Lesson 2, Digestive and Urogenital Systems.

Lesson 3, The Respiratory, Cardiovascular, and Nervous Systems.

Lesson 4, Special Radiographic Procedures

Here are some suggestions that may be helpful to you in completing this subcourse:

--Read and study each lesson carefully.

--Complete the subcourse lesson by lesson. After completing each lesson, work the exercises at the end of the lesson, marking your answers in this booklet.

--After completing each set of lesson exercises, compare your answers with those on the solution sheet that follows the exercises. If you have answered an exercise incorrectly, check the reference cited after the answer on the solution sheet to determine why your response was not the correct one.

Credit Awarded:

Upon successful completion of the examination for this subcourse, you will be awarded 10 credit hours.

To receive credit hours, you must be officially enrolled and complete an examination furnished by the Nonresident Instruction Branch at Fort Sam Houston, Texas.

You can enroll by going to the web site http://atrrs.army.mil and enrolling under "Self Development" (School Code 555).

A listing of correspondence courses and subcourses available through the Nonresident Instruction Section is found in Chapter 4 of DA Pamphlet 350-59, Army Correspondence Course Program Catalog. The DA PAM is available at the following website: http://www.usapa.army.mil/pdffiles/p350-59.pdf.

LESSON ASSIGNMENT

LESSON 1	Special Considerations in Radiography and Fluoroscopy.
TEXT ASSIGNMENT	Paragraph 1-1 through 1-27.
LESSON OBJECTIVES	After completing this lesson, you should be able to: 1-1. Successfully answer questions on the skeletal system, fluorography, spot-film radiography, serialography, stereoradiography, fluid level radiography and soft-tissue radiography.
SUGGESTION	After completing the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 1

FLUOROSCOPIC AND SPECIAL RADIOGRAPHIC EQUIPMENT

Section I. FLUOROSCOPY

1-1. GENERAL

a. Fluoroscopy is one of two general methods of radiographic examination by which an image is produced on the fluorescent screen when the part to be examined is interposed between the energized tube and the fluoroscopic screen. One great difference between the fluoroscopic image and the conventional radiographic image is that the former persists only during x-ray excitation of the screen, thereby permitting only limited time for examination, whereas the latter is a permanent record that can be studied at leisure. Another difference is that in the fluoroscopic image the dense portions of the part under examination appear as dark areas on the screen and the radiolucent portions as light areas whereas the reverse is true of the radiographic image. For instance, the lungs would appear lighter than the heart in a fluoroscope examination but in a radiograph, they would look darker.

b. Fluoroscopy permits observation of gross physiology, which is that physiology concerned with motion of the heart, diaphragm, and alimentary tract; transport of contrast media through the alimentary tract; and so forth. The great value of fluoroscopy lies in the opportunity for correlation of anatomy and physiology, normal or abnormal. Added value accrues through the ready alteration of the patient's position under fluoroscopic observation. This serves to localize an abnormality in relationship to other structures and to establish which positions will be advantageous in radiography. Furthermore, procedures such as progressive filling of sinus tracts or the bronchial tree with contrast medium may be guided fluoroscopically to ensure that films will be exposed at the proper time (that is, neither incomplete outlining nor overfilling).

1-2. APPARATUS

The principal components (in addition to generator, controls, etc.) required for the production and management of the fluoroscopic image are as follows:

a. **X-ray Tube.** The x-ray tube is usually located under the table and is attached to the fluoroscopic tower. It is the source of x-rays for excitation of the fluoroscopic equipment. The National Committee on Radiation Protection and Measurements and TB MED 521 specify that the tube-tabletop distance will be not less than 15 inches (38 cm). TB MED 521 further specifies that the total permanent filtration in the useful beam shall be at least 2.5 mm aluminum equivalent.

b. **Fluoroscopic Shutters.** The fluoroscopic shutters limit the area of the screen illuminated by x-rays. They not only reduce the area of irradiation, but also lessen the effect of SR (scattered radiation or secondary radiation) on patient, staff, and fluoroscopic image. TB MED 521 specifies that the useful beam must be restricted to an area that is less than the lead barrier. When the shutters are open to their fullest extent, they should leave a margin of at least 1/4 of an inch of illuminated fluorescent screen with the screen at its greatest practical distance from the tube.

c. **Image Intensifier.** The image intensifier replaced the fluoroscopic screen, a sheet of leaded glass with zinc-cadmium sulfide coating. The image intensifier is a complex device that receives the remnant x-ray beam, converts it into light (figure 1-1) and increases the light intensity. It is usually contained in an evacuated glass envelope for structural support. The image intensifier is usually mounted with in a metal container to protect it from rough handling.

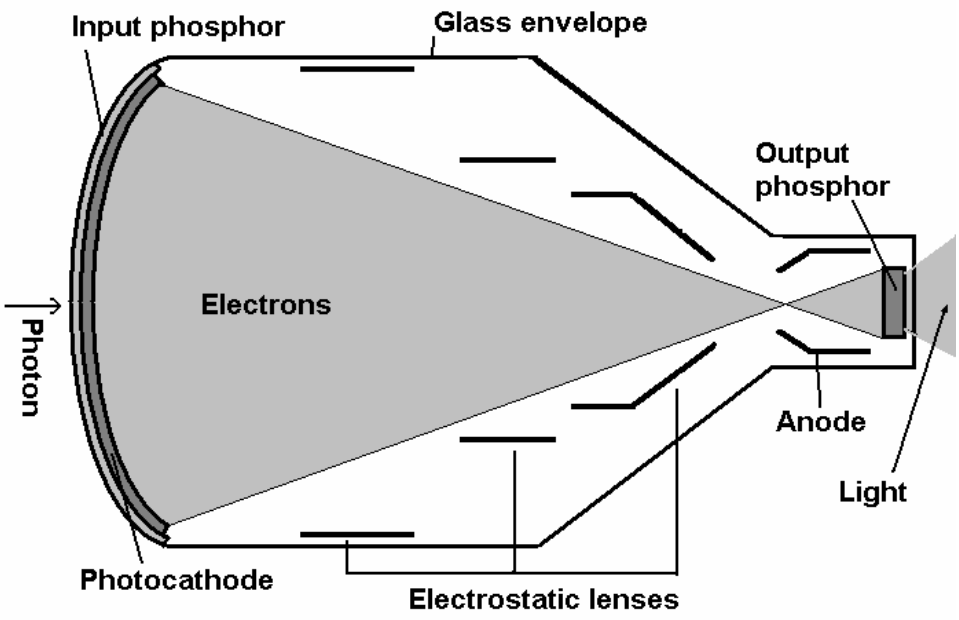


Figure 1-1. An image intensification tube.

1-3. PATIENT, FOCAL SPOT, AND SHUTTER RELATIONSHIPS

Starting from the focal spot, the path of the x-ray beam passes through the filters (inserted between the exit portal of the tube and the shutter), the "open" portion of the shutter, the table top, the patient, the grid (if used), and the image intensifier, the beam is stopped and captured at the input phosphor. The lead glass (which stops most of the x-ray beams) provides protection from the CR for the specialist and radiologist. In the typical fluoroscopic assembly, the tube, shutter, and fluoroscopic screen are arranged to always move together, in any direction, at right angles to the path of the CR. The relationships of the tube-to-screen and of the part-to-screen distances affect magnification and distortion of the image, just as in radiography.

1-4. TECHNICAL FACTORS

Modern fluoroscopic equipment has computer controlled preset techniques. However, if the automatic controls are turned off, the average machine settings for fluoroscopy range from 0.5 to 5 mA (milliamperes), and 90 to 120 kVp (kilovolts peak). Positioning for fluoroscopy depends upon the part to be examined and the patient's condition. In general, part or all of the chest, upper gastrointestinal, and bronchial fluoroscopic examinations are performed with the patient erect; colon and myelographic examinations are usually made with the patient lying on the x-ray table.

1-5. EXAMINATION TECHNIQUE

Examination techniques vary not only for different types of examinations, but also from radiologist to radiologist. Each radiologist develops his own routine procedure for a given examination. All these methods require teamwork between the examiner and the specialists; hence, each must be familiar with the routine procedure to expedite the examination. Chest fluoroscopy usually precedes a gastrointestinal examination and is done with the patient upright if his condition permits. It consists basically of examining the various portions of the chest in various projections and phases of respiration; a swallow of barium paste is used to outline the esophagus. Upper gastrointestinal fluoroscopy is performed with the patient upright at first, later horizontal. Colon studies require the patient to be in a horizontal position. The specialist must know when the radiologist wants a cup of barium mixture handed to the patient, when the empty cup is to be taken from the patient, and when the table is to be tilted in a different position. The radiologist, in turn, seeks to guide the specialist by adhering to a routine in his examination and in his remarks to the patient. The specialist knows, for example, that when the examiner tells the patient, "Face me, now," the next step will be to hand the patient the glass of contrast medium. The patient is not dark-adapted. Therefore, when he steps into the "dark" room, he requires guidance. Effort must be made to allay his worry and fear of the examination. The patient's peace of mind must be assured.

1-6. PROTECTION

The following precautions will be observed:

a. A diagnostic-type protective tube housing will be used with equivalent of 2.0 mm lead (IAW TB MED 521).

b. Distance should be utilized as a protective measure. Radiologic technologists must remain away from the fluoroscopic unit whenever their services are not required in the examination. Decreased distance from the source of both primary and secondary radiation accounts for a greater radiation exposure to the radiologist and radiologic technologist during horizontal, as opposed to vertical, fluoroscopy.

c. Time (duration of exposure) should be kept at a minimum compatible with the completion of the examination. TB MED 521 requires that a manual reset, 5-minute cumulative timing device be used to indicate elapsed time of exposure and to "turn off" the tube energizing circuit at the end of 5 minutes.

d. The size of the field should be kept at a minimum to decrease the amount of scatter radiation and tissue irradiation.

e. The dose rate measured in the CR at tabletop will not exceed 10 roentgens per minute (R/min) for fluoroscopic equipment with automatic exposure control, except during cinefluorographic and spot films. Equipment without automatic exposure control will not exceed 5 R/min.

f. Lead gloves and apron will be worn by the radiologist and by the specialist, who must remain close to the unit to perform his work. The lead equivalent of the apron and gloves will be at least 0.5 mm to 0.25 mm measured at 80 kVp. Lead shields between the sources of radiation and the staff serve the same purpose.

g. Structural shielding for radiographic/fluorographic installations should include 1/16-inch lead or equivalent material to a wall height of 7 feet. (Note: fluoroscopic installations only require 1/32 inch lead or equivalent material.)

h. Equipment will comply with the safety provisions of TB MED 521.

i. The fluoroscopic equipment should be operated only by a medical officer of the department of radiology or by a medical officer properly trained and authorized by the radiologist in charge to conduct fluoroscopic examinations.

1-7. SPOT-FILM RADIOGRAPHY

a. During the fluoroscopic study of gastrointestinal physiology, it is often desirable to record a particular finding on film. This finding may be transitory and capable of visualization only while the patient is in a limited number of positions. For such occasions, it is practical to expose a film quickly and without changing the position of the patient. To provide for such exposures, a spot-film device is utilized. As shown in figure 1-2, the cassette loaded with film is stored in a lead shielded area of the spot-film device. The shielded tunnel arrangement is mounted on the backside of the radiographic table. The moment the pertinent view is located, the examiner releases the foot (or thumb) switch and actives the spot-film exposure button. When the spot-film exposure button is activated, the spot-film device acquires the cassette and brings it into position in over the central ray. During this action, the radiographic tube under the table switches from fluoroscopy to spot-exposure mode. This action happens automatically and the device returns the cassette to the shielded storage area until the button is pushed again.

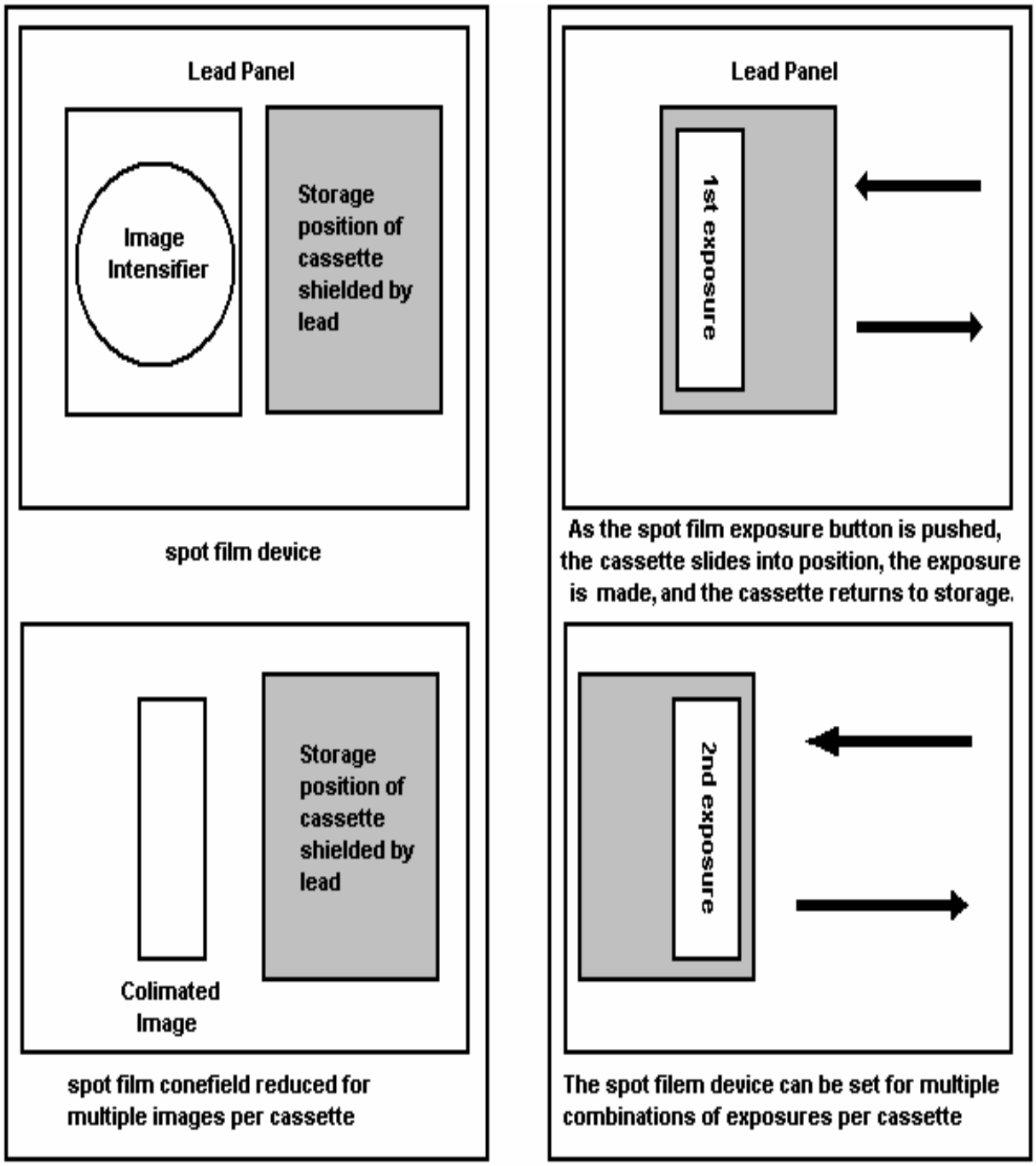

Lead Panel
Image Intensifier
Storage position of cassette shielded by lead
spot film device
Colimated Image
Storage position of cassette shielded by lead
spot film conefield reduced for multiple images per cassette
Lead Panel
1st exposure
As the spot film exposure button is pushed, the cassette slides into position, the exposure is made, and the cassette returns to storage.
2nd exposure
The spot filem device can be set for multiple combinations of exposures per cassette

Figure 1-2. Spot-film radiography and serialography.

b. More modern digital spot-images devices capture and store a digital image for later review and printing as necessary. Modern picture archiving and communication systems (PACS) provide the ability to store and recover patient images for an indefinite period of time. The technique factors for modern equipment are set on the control panel or on the spot-film device by pushing a preprogrammed button. All exposures and techniques are now computer controlled to allow safe use of the equipment for patient and staff.

1-8. SERIALOGRAPH

a. Modern fluoroscopic units incorporate computer controlled spot-film devices that provide a virtually unlimited selection of spot-film arrangements. With an advent of digital fluoroscopy and PACS, the use of serialography is obsolete. When using these units, the specialist needs only to load/unload the cassettes into the spot film device and the radiologist makes film position selections automatically.

b. This procedure, known as serialography, consists of making a number of exposures in series. It may consist of exposing a series of radiographs using single-exposure films or exposures may be made limiting the area of the projected image so that a number of exposures can be recorded on a single film.

c. For instance, as shown in B, B1, and B2 of figure 1-2, the exposed area of the fluoroscopic screen may be confined to half (or even less) the area the film. For the first exposure, the film is moved in front of the non-protected portion of the fluoroscopic screen so that only one portion of it is exposed to the radiation. Following this exposure, it may be moved further so as to provide for exposures onto another portion or it may be moved back into its storage position and subsequent exposures may be made as fluoroscopic findings indicate their value.

d. An electrical or spring device is used to shift the film into the exposed "window" of its storage tunnel so that one or more radiographic images will be produced on each film.

1-9. SERIAL FILM CHANGERS

The serial film changer is mostly obsolete due to the use of digital radiology systems. Digital images are captured by biplane digital imaging plates at a rate set by the technologists and controlled by computer. Individual images can then be store in a PACS or printed on a laser printer. The following is provided for those facilities that have not converted to digital radiography.

a. In angiography, the contrast material introduced into the circulatory system is circulated so rapidly that extremely short intervals between exposures are necessary for adequate demonstration of the vasculature. The intervals between exposures are usually fractions of seconds; thus manual cassette changing is impossible. Biplane digital imaging plates are used to rapidly and automatically capture the image, which permits several radiographs to be made in a very short period of time. They are electrically powered and synchronized with the x-ray generator so that the exposures are automatically controlled.

b. These devices can only be used with x-ray generators specifically wired to accept them. Most of the newer units, fixed or portable, that have a potential of at least 200 mA and 125 kVp are so wired.

c. When the biplane digital imaging plates film changer is connected to the x-ray generator, the hand switch circuit of the generator is bypassed and, on some units, the rotor is activated. Thus, the digital imager controls the x-ray tube and subsequent production of x-rays.

1-10. AUTOMATIC CONTRAST MEDIUM INJECTOR

With the advent of new technologies in computerized tomography and magnetic resonance imaging, contrast material must be injected with sufficient pressure to overcome the patient's systemic arterial pressure and to maintain a bolus to minimize dilution with blood. The flow rate is affected by many variables such as the viscosity of contrast media, length and diameter of the catheter, and injection pressure. There are many types of automatic contrast injectors, including the types pictured in figure 1-3.

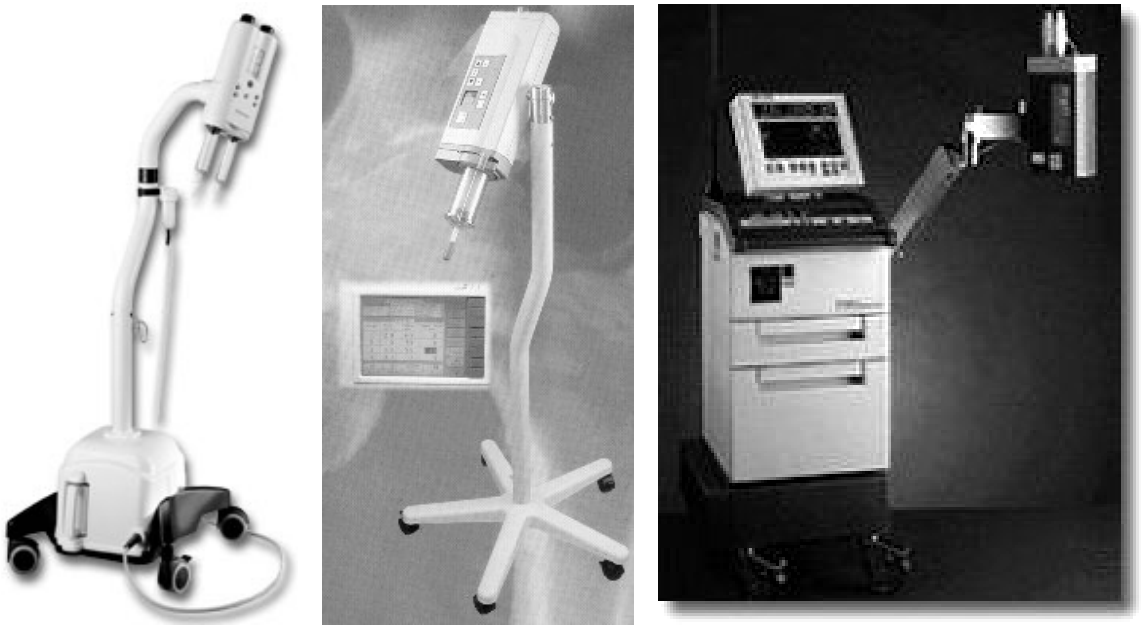


Figure: 1-3. Types of automatic contrast media injectors.

1-11. USE OF TELEVISION

Current fluoroscopic equipment displays the patient under fluoroscopy. The use of television (TV) is an integral part of the fluoroscopic system. Television offers more convenience and mobility for viewers, biplane viewing, and the advantage of video recording.

1-12. VIDEOTAPE RECORDING

a. Videotape recording is a means of electronically recording the fluoroscopic image. In contrast to cine, which uses the photographic process to record the image on film, a videotape recorder uses magnetic tape.

b. In the recording phase of operation, the video signal produces a varying magnetic field at the recording head, which imprints the signal information on the magnetic tape. In the playback phase, the information on the tape is converted back into a video signal that is displayed on a monitor much the same as the original signal. Videotape recording offers several advantages over cine recording. Among them are lower radiation dose to the patient, no processing, instant playback, and the reusability of the tape. The major disadvantage is that resolution is somewhat lower than with cine. Consequently, videotape may not be practical when high resolution is required. However, since instant playback is possible with videotape, it can be used in addition to cine to determine if the information recorded on the cine film is adequate. Using videotape as back-up device in this manner eliminates the necessity of having the patient remain in the radiology department until the cine film is processed.

Section II. SPECIAL TECHNIQUES AND EQUIPMENT

1-13. IMAGE INTENSIFICATION

Image intensification relates to a method of producing fluoroscopic images characterized by a high level of brightness. The light gain of an x-ray image intensifier may be defined as the ratio of brightness on the apparatus to the brightness of a standard fluorescent screen, both excited by the identical intensity of radiation. One of the uses of an image intensifier is for doing cinefluorography.

1-14. PRINCIPLES OF IMAGE INTENSIFICATION

a. The basic component use for effecting image intensification is essentially a type of electronic tube (figure 1-4) used in conjunction with an x-ray source, an electrical energizing and controlling system, and an optical system.

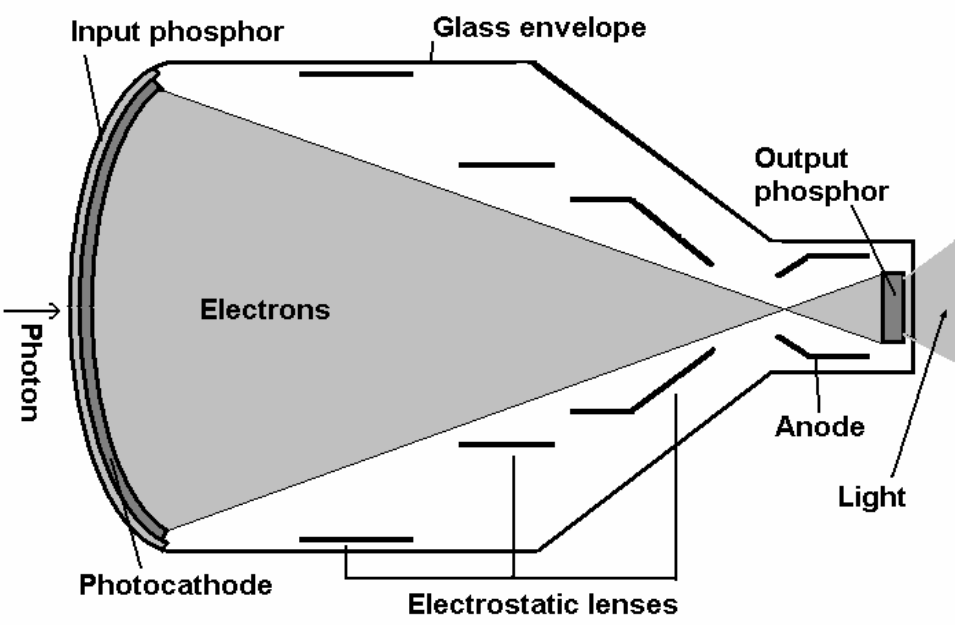


Figure 1-4. An image intensification tube.

b. In the main, the functional aspects of a typical image intensifier tube are as follows:

(1) X-rays, having passed through the patient, impinge on a fluorescent element, or image input phosphor, at the input end of the image intensifier tube. This fluorescent layer then emits light proportional to the x-ray beam impinging on it. A photoelectric layer (photocathode), which is in direct contact with the input phosphor, emits electrons proportional to the light image produced by the fluorescent layer, thus converting the light image into an equivalent electron image. The primary reasons for the conversion of x-rays to light and light to electrons are that x-rays cannot be focused, and they, by themselves, cannot be amplified or accelerated. Once the image is converted into an electron image, it can be electronically amplified and focused.

(2) The electrons comprising the image are accelerated by the accelerating and focusing electrodes to high speeds by the application of high voltage placed across the highly evacuated tube. The photoelectron current is then focused by a low potential on the inside metallic coating of the tube so that it passes through the anode aperture.

(3) The paths of the high-energy electrons flowing from the image-input phosphor converge at a point and are electrostatically focused on the face of the output phosphor, forming bright image on the output phosphor. The output phosphor consists of materials similar to the front of the ordinary television picture tube that will give off light when struck by high-energy electrons. This conversion of electrons to light is necessary for visualization of the image.

(4) The total amount of image intensification or total gain is based on electronic intensification and minification. A high positive voltage (25 to 30 kV) applied to the accelerating electrodes speeds up the electrons emitted to the photo cathode. This accounts for a gain in light intensity of approximately 35 to 45 times. Minification is determined by the ratio of the input phosphor to the output phosphor. For example, if the input area of a 9-inch tube is 9 by 9 inches, or 81 square inches, and the output diameter of this same tube is 1 inch (with an area of 1 square inch), the minification factor is 81:1. The total intensification or total gain is equal to the amount of electronic intensification multiplied by the minification factor. A tube having an electronic intensification of 40 and a minification factor of 81 would have a total gain of 3,240; meaning the image would be 3,240 times brighter than a fluorescent screen excited with the same amount of radiation.

(5) A lens system, which is actually part of the viewing system, collects and collimates the light emitting from the output phosphor.

c. Image intensifiers are rated at 5, 8, 9, and 11 inches. This does not relate to the field size covered, but to the diameter of the input phosphor. The 8-inch and 9-inch image intensifiers are generally preferred for fluoroscopy and/or cinefluorography.

d. Another development is the dual field tube. In effect, it provides a 6-inch or 9-inch input phosphor at the same time so that the fluoroscopist may use either the 6-inch or 9-inch mode at will. By changing the focusing voltages, the minification factor is changed. When using the 6-inch mode, the center 6-inch square of the 9-inch input phosphor is transmitted to the same output phosphor as used for the 9-inch mode. Since the input/output ratio is 6:1, the image will be larger, but part of the amplification is lost. This image enlargement pertains to the dual field tube. Standard image tubes amplify the intensity of the light image, but do not enlarge it.

1-15. BASIC OPERATIONAL CONSIDERATION

a. **Installation.** A typical image intensifier unit is usually mounted upon a motorized stand balanced with counter-weights that allows easy maneuverability (figure 1-5). To set up for the procedure, the intensifier unit is moved into position, the shielding in moved into place, and the spotfilm device is loaded. After the necessary connections and adjustments have been made, image-intensified fluoroscopy can be accomplished. The x-ray table unit may be titled as for conventional fluoroscopy (figure 1-6).

Figure 1-5. A typical x-ray image intensifier.

Figure 1-6. Image intensifier unit hooked up with an x-ray unit and in position for vertical fluoroscopy.

b. **Viewing.** The image intensifier tube creates a fluoroscopic image that is many times brighter than a conventional fluoroscopic screen, but this image is too small to be of value. Therefore, a means of magnifying and viewing the image is necessary.

(1) An efficient magnification and viewing system should meet the following requirements:

(a) Enlarge the part to approximately life size or greater.

(b) Provide an image for both eyes simultaneously (binocular).

(c) Place minimum restrictions on the user.

(d) Not degrade the resolution of the image.

(e) Not degrade the contrast of the image.

(f) Provide viewing for two or more people simultaneously.

(g) Efficiently gather the light generated at the output phosphor.

(2) Magnification is now controlled by the image intensifier with the ability to control the field size. Observation is now open to anyone that can see the screen of the digital monitor; and there is often a monitor in the control-room as well as the radiologist's office.

(3) To permit TV monitors, cine cameras, or videotape recorders to be used with an image intensifier, a beam-splitting device is used. It is made of plate glass coated with a special layer that reflects part of the incident light and allows the remainder to be transmitted. The beam splitter channels the image to different devices; therefore, the intensity of each image is reduced. To maintain the same light intensity, the technique must be increased, which will result in increased patient exposure. If only one medium of visualization is used, the beam splitter can be moved out of the way.

c. **Focusing.** Focus depends upon the voltage applied across the electrodes of the image-intensification tube. Poor electrostatic focus may cause unsatisfactory image detail. Focus may be checked by observing the resolution obtained from a suitable test object, such as an area of the fine-meshed wire. The resolution capability of an image tube is a measure of its ability to show physiological detail. To do so, it must depict discrete parallel lines of equal width, spaced by an amount equal to the width of each line. These are called line pairs and consist of one black line and one space. To perceive the border of a certain area, this border must be darker or lighter than its surroundings. The contrast between two areas must have a certain minimum value to be visible by the human eye. The contrast of the image is not improved by amplification. If greater contrast is desired, contrast media are used.

d. **Kilovoltage and Milliamperage.** These factors depend on the size and density of the subject under examination and on the level of image brightness desired. Kilovoltages ranging from 70 to 120 kVp at an x-ray current of 1/2 to 2 mA are commonly used. Insufficient current (mA), especially when high kVp is used, may cause the image to lack definition and appear grainy. When this image is viewed in motion, a coarse, mottling effect is apparent. This is the result of scintillation or "quantum noise," and it occurs when the level of x-radiation falls below a given minimum. In other words, there is a level of radiation below which an image of good quality cannot be obtained. The quantum noise in the intensified image is inversely proportional to the number of x-ray photons absorbed in the fluorescent layer of the input phosphor within the integration time of the human eye, which is approximately 0.2 seconds.

NOTE: During fluoroscopy, the radiation dose necessary to create an image must be delivered during the integration or recognition time of the eye, while during cinefluorography, the radiation required to create the image must be delivered during the exposure time for each frame of the motion picture.

1-16. DUTIES AND RESPONSIBILITIES OF THE X-RAY SPECIALIST

a. The x-ray specialist's duties and responsibilities in the performance of image-intensified fluoroscopy and cinefluorography are much the same as for conventional fluoroscopy for the other procedures. Radiation hazards do exist and the x-ray specialist must be just as careful to take the same precautions as for ordinary fluoroscopy.

b. To function efficiently as a member of the team, he must have a practical understanding of the equipment and their uses and of the technical mechanics of the procedure. For this reason, the x-ray specialist who is to assist in image-intensification work should study the manual of instructions for the particular unit, as well as any other available literature. With this knowledge, he will be better prepared to carry out the radiologist's orders.

1-17. DENSITY EQUALIZATION FILTERS

a. Density equalization filters are special accessory devices used when it is desirable to cause a variation of x-ray intensity across a given beam. When the filter is introduced into the path of the x-ray beam, its intensity is modified in differing degrees over given portions of the file being irradiated (figure 1-7). This is achieved by selective absorption.

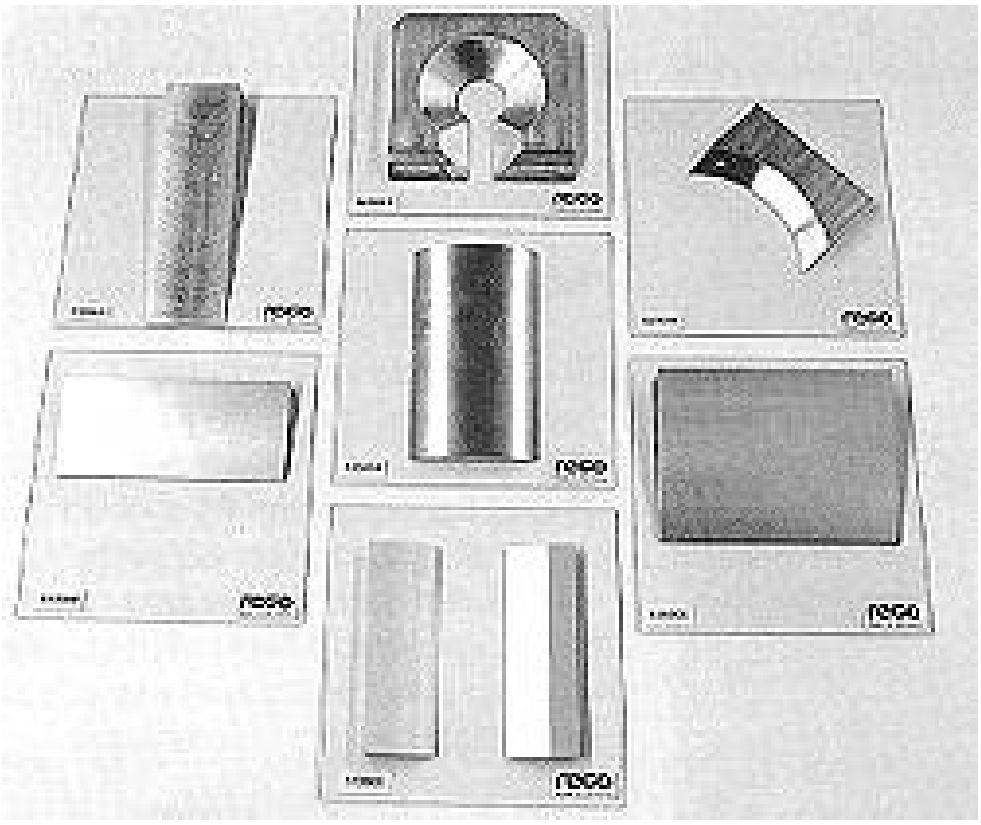


Figure 1-7. Density equalization filters.

b. These devices are especially effective where the part or areas to be examined present widely varying densities, all of which must be satisfactorily demonstrated on one film. For example, in making the dorsoplanter projection of the foot (figure 1-8), dorsoplanter or plantodorsal projections of the os calcis, lateral placentograms, and examinations of the thoracolumbar region are needed. When normal radiographic techniques are used to demonstrate such parts, it usually happens that if the thin parts of the subject are properly exposed, the thick parts may be considerably underexposed. Conversely, gross overexposure of thin parts may occur in the exposure factors or are adjusted for satisfactory demonstration of the thick parts. This problem can be corrected by the proper use of the density equalization filters. Also, the absorbed radiation dosage to the patient is decreased.

c. Filters of this type are sometimes referred to as compensating filters, wedge filters, differential-absorption filters, supplementary filters, or balancing filters.

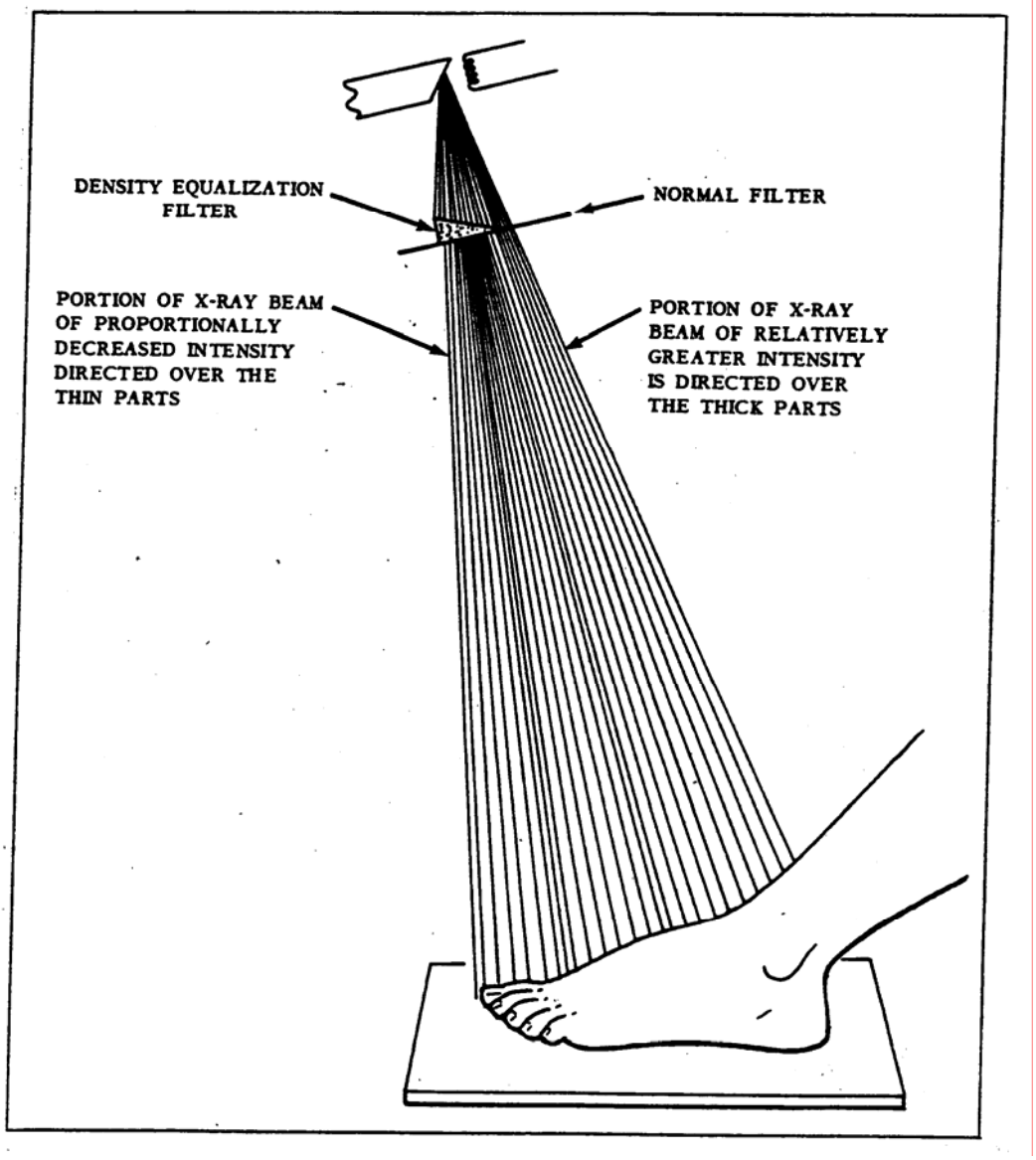

DENSITY EQUALIZATION FILTER
NORMAL FILTER
PORTION OF X-RAY BEAM OF PROPORTIONALLY DECREASED INTENSITY DIRECTED OVER THE THIN PARTS
PORTION OF X-RAY BEAM OF RELATIVELY GREATER INTENSITY IS DIRECTED OVER THE THICK PARTS

Figure 1-8. Relationships of the density equalization filter, the x-ray cone (or bean), and the thin and thick parts of the anatomical structure being radiographed.

1-18. COMPOSITION AND CONSTRUCTION

a. Density equalization filters may be made up of the following materials:

(1) Aluminum.

(2) Brass.

(3) Copper.

(4) Opaque plastic paste-like mixture (commercially available) that is especially suited for this purpose.

(5) Barium sulfate-impregnated paste.

b. Density equalization filters are usually made up in characteristically sloped or wedge-like forms by modeling if a paste-like substance is used or by grinding if a metallic substance is used.

c. Density equalization filters should be built to fit a particular type of examination. For example, a filter made of brass with a heel thickness of approximately 1/8-inch may be practical for making placentograms, but unsatisfactory for making full-length venograms of the lower extremities.

d. These filters should be fabricated in such a way as not to cause the superimposition of distracting densities over any part of the resulting image pattern.

1-19. WHERE DENSITY EQUALIZATION FILTERS MAY BE INTRODUCED

Density equalization filters may be introduced into the x-ray beam at the level of the filter slot near the x-ray tube housing where the normal complement of filters is usually located or at the level of the exit portal of the beam-restricting device or they may be interposed between the part and the film. The normal equivalent of filtration is always retained where any type of density equalization filter is used. In every case, the filter is an addition to the normal filter system.

1-20. BASIC PRINCIPLES

a. The density equalization filter (figure 1-8) must be oriented in the path of the x-ray beam in such a way that its "heel" (thicker-edge) portion is toward the thinner or less-dense portions of the part or area to be radiographed.

b. Whenever a density equalization filter is introduced into the path of the x-ray beam, the exposure factors should be adjusted to deliver sufficient x-ray intensity to achieve optimum visualization over the thickest and densest portions of the part or area under consideration.

Section III. CONTRAST MEDIA

1-21. INTRODUCTION

a. **Photo Absorption.** It would be difficult, if not impossible, to produce diagnostic radiographs of arteries, veins, cavities, or passages without special contrast media. Radiographic contrast is made possible by the selective absorption of x-ray photons. However, photon absorption by a structure that is surrounded by structures of equal or similar densities is not sufficiently selective to produce adequate radiographic contrast. In cases where structure densities are similar, contrast media are used to alter the photon absorption and, therefore, produce the necessary radiographic contrast. The radiographs in figure 1-9 A, B and C, illustrate how a contrast medium alters photon absorption to allow visualization of the stomach. Radiograph 1-9 A is a plain film of the abdomen. The stomach is not seen because its density is similar to the surrounding structures. Radiograph 1-9 B shows that the radiographic contrast between the stomach and surrounding structures has been enhanced because the stomach has been filled with a contrast medium that increased the photon absorption. Radiograph 1-9 C shows the stomach filled with air. In this case, contrast has been improved over that of A because photon absorption has been decreased.

b. **Radiopaque and Radiolucent Contrast Media.** Contrast media that increase photon absorption are termed radiopaque (positive) contrast media and are made from substances of high atomic numbers, such as iodine and barium. Media that decrease photon absorption are classified as radiolucent (negative) contrast media and are substances with low atomic numbers, like gases. These media are sometimes referred to as positive and negative media; however, in this subcourse, they will be termed radiopaque and radiolucent.

c. **Toxicity.** It should be noted that regardless of atomic number, a contrast medium must not be excessively toxic to the patient. If, for example, pure iodine or pure barium were used as a medium, the patient would become violently ill. This is because iodine and barium in their natural states are poisons. So the two requirements for a good contrast medium are that it must change photon absorption and that it must be relatively nontoxic. In the case of iodine and barium, low toxicity is obtained by chemically combining them with other elements.

d. **Grouping of Contrast Media.** In this subcourse, we will consider contrast media grouped by chemical makeup and usage. Media that are chemically similar and those used for the same examination are grouped together. Three examples of such groups are oral, injectable, and noninjectable contrast media. These terms are rather general, so more specific groupings will also be discussed.

Figure 1-9 A. Film showing no gastrointestinal contrast medium

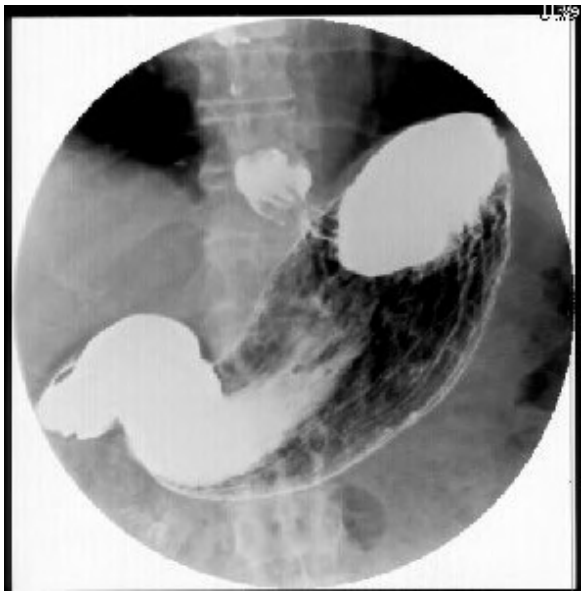


Figure 1-9 B. Stomach with contrast medium.

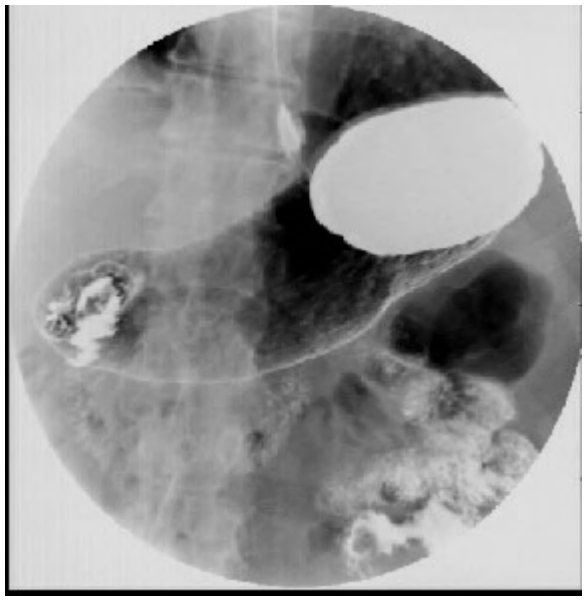


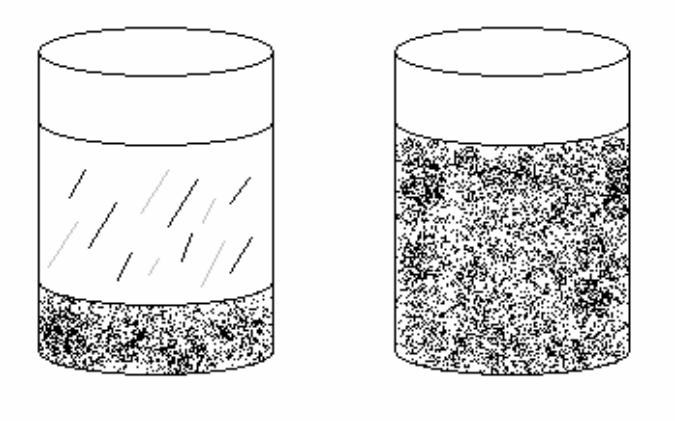
Figure 1-9 C. Stomach with some of the contrast medium displaced by air.

1-22. ALIMENTARY TRACT RADIOPAQUES

a. **Barium Sulfate Radiopaques.** Two typical contrast media used for examining the alimentary tract are Barium Sulfate, U.S.P (United States Pharmacopoeia) and Barosperse. Since they are based on barium sulfate, they form a subgroup called barium sulfate preparations.

NOTE: The United States Pharmacopoeia is a listing of the accepted standards for compounding drugs.

(1) Both of the mixtures seen in figure 1-10 are barium preparation and water. They were stirred at the same time and allowed to sit for ten minutes. Notice that Barium Sulfate, U.S.P. settles out of suspension rapidly while Barosperse stays in suspension longer. Barosperse is a barium sulfate derivative that is micronized and ionized so that it stays in suspension longer. It should be noted that barium sulfate is not water-soluble; when mixed with water, it is in suspension rather than in solution.



Barium Sulphate, U.S.P. Barosperse

Figure 1-10. Comparison of Barium Sulphate, U.S.P., and Barosperse after being stirred and resting a few minutes.

(2) Micronization is a process of grinding things to extremely small particle size. Ionization is the application of like charges to all particles in an ionized medium. Since like charges repel, the forces of repulsion hold the smaller particles in suspension longer. A glass-stirring rod should be used to stir this preparation. Ionized media should not be prepared with a mechanical mixer, metal spoon, or in a metal container because metal provides a conducting pathway resulting in neutralization of the charged particles. The repelling process of the particles is illustrated in figure 1-11.

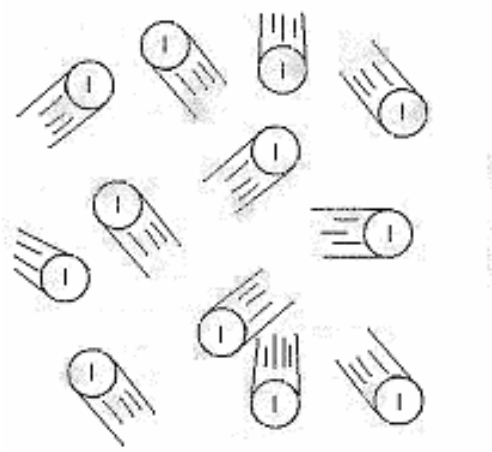


Figure 1-11. Particles of barium repelling one another in Barosperse.

b. **Alternate Alimentary Tract Radiopaques.** In figure 1-12, barium sulfate was ingested during an upper G.I. The patient did not drink adequate liquids to flush barium from his system, resulting in fecal impaction. The water is absorbed, leaving a residue of barium sulfate particles. These particles would irritate the tissue they come in contact with. This could result in inflammations, adhesions, or other undesirable complications. Contrast media used when gastrointestinal perforations are suspected should be soluble to avoid leaving an irritating residue. To achieve this end, pharmaceutical companies adjust the activity of water-soluble injectable media to nearly neutral. This renders them suitable for oral use. Two examples are Oral Hypaque and Gastrografin. These soluble media leave no particles as residue. Therefore, they are used as alternates in the alimentary canal when perforations are suspected.

c. **Cholecystopaques.** The biliary tract is examined with a group of contrast media called cholecystopaques. These contrast media are chemically compounded to be selectively excreted along with bile, by the liver. They may be oral or injectable.

(1) Oral cholecystopaques. One example of the oral type of cholecystopaques is Telepaque. Available in tablet form, it is packaged in foil, six tablets to the package. Instructions for their use are found on the package. The tablets are dissolved in the stomach and absorbed by the mucosa of the small intestine, specifically the duodenum and proximal jejunum. The portal system of veins carries the dissolved media from there to the liver. The liver then excretes the media along with bile. Telepaque and other oral cholecystopaques are employed in oral cholecystography.

(2) Injectable cholecystopaques. The other type of cholecystopaque is injectable; therefore, it is called an intravenous cholecystopaque. One example is Cholografin. This water-soluble medium is compounded specifically to be excreted by the liver. Intravenous cholecystopaques are used for intravenous cholangiography. Intravenous cholangiography is employed to visualize the biliary tract when the oral method has failed in cases of poor intestinal absorption or after gallbladder surgery.

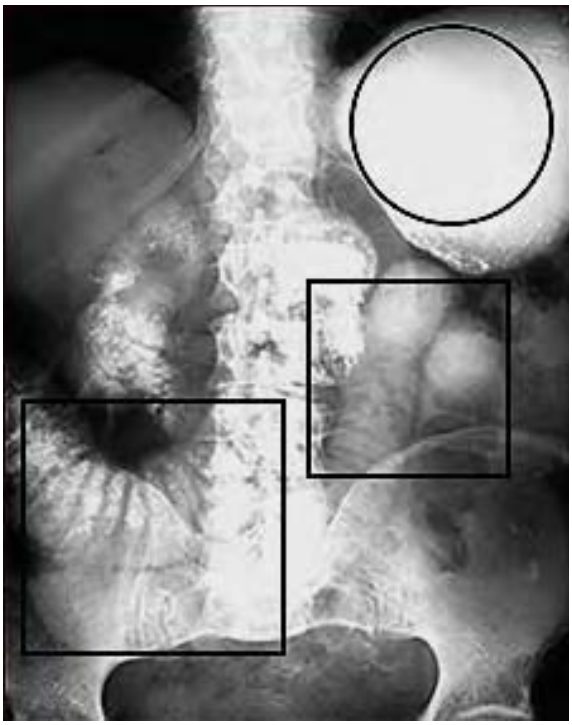


Figure 1-12. Demonstrated barium impaction following an upper GI.

1-23. WATER-SOLUBLE RADIOPAQUES

a. **Introduction.** The largest, most versatile, group of contrast media is the water-soluble radiopaques. Made of iodine compounds, this type of media can be used in radiographic studies of the urinary system, the cardiovascular system, joint spaces, and connective structures, as well as many other radiographic examinations. There are two types of water-soluble contrasts, injectable and noninjectable.

b. **Water-Soluble Injectables.** The water-soluble injectables are categorized into two groups according to their weight-by-volume concentration. Although the dividing line in practice is somewhat vague, those media of lower concentrations are used for general purposes while those of higher concentration are normally reserved for examination of the heart and great vessels. Weight-by-volume concentration does not refer to the iodine content of a particular medium, but to the concentration of the iodine compound. For example, in 100cc (cubic centimeter) of Renografin 60 percent, 60 percent of the weight is the compound methylglucamine diatrizate and 40 percent of the weight is sterile water. On the other hand, the iodine content of this medium is approximately 29 percent.

(1) In 1984, a new generation of contrast media was introduced in the U.S. that also contains iodine as needed for opacity but contains no positive-charged ions, thus called non-ionic contrast. These new contrasts have a low osmolality and fewer severe contrast reactions are experienced. A common non-ionic contrast used is Isovue – 300 (Iopamidol Inj 61 percent I.V.).

(2) Hypaque 50 percent, Conray 50 percent, and Renografin 60 percent are water-soluble injectables of relatively low concentrations. Frequently used for urographic studies, they are generally termed urographic media. These media can also be employed in contrast examinations of joints and portions of the cardiovascular system.

(3) The more concentrated water-soluble injectables are usually reserved for examinations of the heart and great vessels. Hypaque M (75 percent or 90 percent concentration), Angio-Conray 80 percent, and Renografin 76 percent are examples of this group, generally titled angiocardiographic media.

c. **Water-Soluble Noninjectables**. The other kind of water-soluble radiopaques is called noninjectable. Retrografin is a typical example. They are primarily used in retrograde studies of the urinary tract. These media are modified injectables. For instance, Retrografin is essentially Renografin with neomycin, an antibiotic, added. In this case, contrast media and antibiotics are mixed to reduce the danger of infection following retrograde examinations.

1-24. VISCOUS AND/OR OILY RADIOPAQUES

a. **Introduction.** Ethiodol, Salpix, Pantopaque, and Dionosil are examples of a group of contrast media called viscous and/or oily radiopaques. These viscous or oily radiopaques are rarely used today since the exams that used them have been replace by exams done in other modalities.

b. **Viscosity and Oiliness.** The reason for the "and/or" above is understood if an analogy is made with a jar of honey, a can of light lubricating oil, and a can of motor oil. The honey is viscous, meaning thick or resistant to flow, but not oily. The light oil is oily, but not viscous. The motor oil is both viscous and oily. The contrast media in this group have various combinations of viscosity and oiliness.

c. **Uses of Viscous and/or Oily Media.** The bronchial tree can be studied by introducing Dionosil or a similar medium. Dionosil, a viscous and oily medium, is used to prevent flow of the contrast agent into the alveolar sacs, and because it is absorbed by the lungs leaving no residue. Salpix is usually used to delineate the uterus and fallopian tubes in hysterosalpingography. Salpix is a water-soluble, viscous medium. Ethiodol, an oily viscous medium, is usually employed in the radiological examination of the salivary glands. Pantopaque that is both viscous and oily is used in myelography (the examination of the spinal cord).

1-25. RADIOLUCENT MEDIA

a. **Introduction.** Alimentary tract radiopaques, water-soluble radiopaques, and viscous and/or oily radiopaques are all classified as radiopaque media because they increase photon absorption. Contrast media that decrease photon absorption are termed radiolucent media.

b. **Radiolucent Media and Their Uses.** Oxygen, carbon dioxide, and room air are commonly used as radiolucent media. These common gases are utilized in digital subtraction angiography and joint spaces, as well as for double contrast in certain examinations. Radiolucent media are sometimes used in arthrography. Although the contrast provided this way is quite subtle, some physicians prefer the radiolucent media since it causes less irritation and is quickly absorbed. A radiolucent medium is also commonly used as a double-contrast enema to evaluate the colons for polyps.

1-26. REACTIONS TO CONTRAST MEDIA

a. **Introduction.** Intravenously injected contrast media can produce a reaction similar to anaphylactic shock. True anaphylaxis is the result of hypersensitivity to a drug to which the patient previously was not sensitive. For example, the first time a patient receives penicillin, he may show no side effects; yet, following a second dose of the same drug, this patient may have an anaphylactic reaction. This is thought to be due to the formation of antibodies against a drug. Reactions to contrast media can occur in patients who may or may not have had the particular radiopaque before. Although the causes of contrast media reactions seem to be different, the symptoms are so similar that they are generally thought of as a variety of anaphylaxis. Basically, two types of reactions can occur following the injection of contrast media. They are classified as histamine imbalance and hemodynamic reactions.

b. **Histamine Imbalance Reaction.** Histamine, a substance found in all humans, has several functions, one of which is the release of blood plasma through capillary walls to body tissue. This release of fluids produces swelling of tissue called edema. Histamine is held in check by a histamine inhibitor and, in some people, the balance between the two is delicate and rather easily upset. These people are the unfortunate individuals who suffer from allergies such as hay fever.

(1) One of the theories about histamine imbalance is that iodinated contrast media damage the histamine inhibitor sufficiently to cause an overabundance of histamine. This imbalance causes the release of fluids into tissue, producing a set of distinct, easily recognizable signs and symptoms.

(2) Among the signs and symptoms of a histamine imbalance reaction are itching, a flushed appearance, watery eyes, faintness, hives, nausea, and breathing difficulties. In a mild response of this type, the patient may feel hot, faint, or nauseated. A moderate reaction might evoke watering of the eyes, localized swelling (especially of the face and hands), and a flushed appearance. In its most serious form, breathing problems due to swollen bronchial passages appear. Untreated severe bronchial constriction can produce death by suffocation. Generally, this reaction occurs quickly, but the specialist must be watchful for possible delayed reactions.

c. **Hemodynamic Reaction.** Hemodynamics refers to the characteristics of blood action or flow. A hemodynamic reaction to contrast media has serious effects on blood flow, and can result in such complications as systemic shock, myocardial infarction, and renal shutdown.

(1) Systemic shock is caused by a drop in blood pressure occurring after the introduction of contrast media. The characteristic course is an immediate, but short-lived, increase in blood pressure followed by an acute drop in blood pressure. The immediate rise is produced by increased heart action; then, trying to compensate, the veins dilate. Because of this venous dilation, blood pressure drops and there is not an adequate return of blood to be oxygenated. Cardiac arrest can result if enough blood is retained by the veins.

(2) Myocardial infarction (the death of heart muscle tissue) and renal shutdown are thought to be the product of damage to red blood cells. Some investigators feel the contrast media damage the cell walls of erythrocytes, causing them to clamp together to form clots. If enough of these clots block the internal blood supply, renal shutdown occurs. Similarly, myocardial infarction is caused by the obstruction of the coronary arteries. Either of these complications can be fatal.

(3) The symptoms of this hemodynamic response are a weak and barely noticeable pulse, paleness, cyanosis, and possibly even unconsciousness. Like the histamine reaction, this response may be immediate or delayed.

d. **Patient Histories.** Reactions to contrast media cannot be predicted, but many doctors feel that the probability of a reaction can be assessed by evaluating the patient's history. The radiologist should consult the patient's medical records for a past history of reactions to contrast media or drugs. If he has full confidence in an x-ray specialist, he will probably delegate to him the responsibility of explaining the examination to the patient and questioning him for clues to the possibility of a reaction. In such a case, the specialist must use the utmost tact to avoid alarming the patient. He should ask:

(1) Have you had this or a similar examination before?

(2) Did you have any difficulties with the previous examination? If he answers in the affirmative, ask him:

(3) If he answers "yes" questions (1) and (2), ask: "Do you remember the name of the drug that caused your difficulties?"

(4) If he answers "no" to questions (1) and (2), ask:

(a) Are you allergic to iodine?

(b) Does seafood affect you in any special way?

e. **Allergy.** If the patient indicates that he is allergic to iodine, that seafood makes him sick, or that he had problems during a previous examination, the probability of a reaction is increased. Regardless of the outcome of the questions, the specialist should report his findings to the injecting physicians, preferably outside the exposure room so that the patient cannot hear the conversation.

1-27. EMERGENCY TREATMENT OF REACTIONS

a. **Emergency Equipment.** Whenever iodinated contrast media are administered intravenously, emergency equipment must be immediately available. This equipment normally includes an emergency tray, a cut-down tray, and an oxygen therapy apparatus.

(1) Although the exact content of an emergency tray is determined by the radiologist, it will include several sizes of needles, a variety of syringes, graduated sizes of endotracheal or oropharyngeal airways, a blood pressure cuff, a stethoscope, a tourniquet, intravenous fluids, and drugs. The needles and syringes are used to administer the drugs; the airways are special tubes for maintaining an open air passage, and the stethoscope and blood pressure cuff are used to monitor the patient's blood pressure and heartbeat. A tourniquet is needed to locate a vein for injections, intravenous fluids to raise blood pressure, and drugs to counteract the reaction.

(2) Some of the emergency treatment drugs may be cardiac stimulants such as Epinephrine, blood pressure elevators like Levophed, and antihistamines such as Benadryl. These are typical examples, but the radiologist may choose others.

(3) The oxygen therapy equipment is there to aid the patient's respiration. It may be a Reuben (Ambu) bag (a device for pumping air into the patient's lungs) or an oxygen bottle and mask.

CAUTION: Do not attempt to use this equipment unless you are specifically trained for it.

(4) To maintain an open airway, a tracheotomy or cricothyroid puncture may become necessary. For this purpose, cut-down trays or cricothyroid puncture needles must be readily available.

(5) Do **not** try to administer any drugs nor perform any operations for which you have not been fully trained. Such action may harm the patient and make you liable for legal action.

(6) The radiologist will specify the items to be used as emergency equipment, but you, the specialist, are responsible for its upkeep. Periodically check the operation of the oxygen apparatus. Drugs and sterile packs must be up-to-date and is good supply. If any items are used, they should be replaced as soon as possible.

b. **Emergency Treatment.** The specialist's primary responsibilities are to recognize a reaction, call a physician, take necessary life-saving action, and aid the doctor in treatment. During special procedures using contrast media, the specialist must be on guard for a reaction. Close observation of the patient and thorough knowledge of the signs of a reaction are absolutely necessary. Never leave the patient unattended at any time.

(1) In the event of a reaction, your immediate response should be to call a doctor, preferably the physician who made the injection. It may become necessary to treat the patient for shock by turning his head to the side, elevating his feet, and keeping him warm or cool as the case warrants.

(2) In serious cases, breathing assistance or cardiac massage may be required. Mouth-to-mouth resuscitation is the most effective respiratory method, and you should learn external cardiac massage. Above all, do not panic. A calm, professional demeanor will aid in keeping the patient calm and secure.

(3) When assisting the physician, you may be directed to prepare drugs for injection. The bottle or vial from which the drug was drawn should be shown to the doctor when handing him the filled syringe. The best assistance you can give the physician is a fast and accurate response to his orders. Knowing exactly where to find each item of the emergency equipment is a must!

(4) Remember that the specialist should not administer any drugs, use any equipment, or perform any operations for which he is not completely trained.

Continue with Exercises

EXERCISES, LESSON 1

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the question or best completes the incomplete statement.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. Contrast media are useful where photon absorptions among structures is:

   a. Great.

   b. Negligible.

   c. Similar.

   d. Dissimilar.

2. Radiopaque contrast media are called _____, and radiolucent contrast media are called_____.

   a. Positive, negative.

   b. Weak, strong.

   c. Nontoxic, toxic.

   d. Light, heavy.

3. A good contrast medium must change photon absorption and yet be as _____ as possible.

   a. Liquid.

   b. Lightweight.

   c. Thick.

   d. Nontoxic.

4. Barosperse is different from barium sulphate U.S.P. because it is:

    a. Micronized and ionized.

    b. Water-soluble.

    c. Injectable.

    d. Residue-free.

5. No metal should be allowed to come in contact with a radiopaque media that is:

    a. Iodinated.

    b. Radiopaque.

    c. Ionized.

    d. Radiolucent.

6. Because of possible peritoneal inflammation, _____ contrast medium is contraindicated for use in the perforated alimentary tract.

    a. Barium.

    b. Iodine.

    c. Ionized.

    d. Radiopaque.

7. Cholecystopaques are contrast media used to demonstrate the:

    a. Pancreas.

    b. Large intestine.

    c. Kidneys.

    d. Bile ducts.

8. Water-soluble radiopaques consist of _____ compounds.

    a. Barium.

    b. Iodine.

    c. Methyl.

    d. Glucide.

9. Three water-soluble injectables mentioned in the subcourse that are considered low in concentration are:

    a. Hypaque 50 percent, Cystokon, and Renografin 60 percent.

    b. Retrografin, Conray 60 percent, and Renografin 60 percent.

    c. Hypaque 50 percent, Conray 50 percent, and Renografin 60 percent.

    d. Telepaque, Hypaque 50%, and Renografin 60 percent .

10. Water-soluble injectable contrast media of higher concentrations are normally used only for examinations of the:

    a. Liver and bile ducts.

    b. Kidneys and ureters.

    c. Cranial veins.

    d. Heart and great vessels.

11. Water-soluble noninjectable contrast media are used primarily for the:

    a. Liver.

    b. Urinary tract.

    c. Small intestine.

    d. Large intestine.

12. Oxygen, carbon dioxide, and room air, used in contrast media, are classified as:

    a. Radiopaque.

    b. Radiolucent.

    c. Viscous.

    d. Highly irritating.

13. Radiolucent media are used for:

    a. Arthography.

    b. Double-contrast.

    c. Both a and b above.

    d. None of the above.

14. The two kinds of drug reaction seen with contrast media are histamine imbalance and:

    a. Hemoglobinopathy.

    b. Globus pallidus.

    c. Paraphrenia.

    d. Hemodynamic reaction.

15. A histamine imbalance reaction to contrast media may cause "hay fever" symptoms. The most serious possible result of histamine imbalance is that it may cause:

    a. Liver failure.

    b. Bronchial constriction.

    c. Myocardial infarction.

    d. Stomach cramps.

16. A drug reaction classed as hemodynamic could result in:

    a. Renal shutdown.

    b. Myocardial infarction.

    c. Systemic shock.

    d. Responses b, c, and d above.

    e. None of the above.

17. In case of a reaction to contrast media, emergency equipment nearby should include:

    a. Needles and syringes.

    b. Stethoscope and blood pressure cuff.

    c. Tourniquet, I.V. fluids, and drugs.

    d. Oxygen equipment and airways.

    e. All of the above.

    f. None of the above.

18. Emergency tray items are all easy to use and the x-ray specialist can feel free to use them without any special training.

    a. True.

    b. False.

SPECIAL INSTRUCTIONS FOR EXERCISES 19 THROUGH 21. Match the descriptions in the right hand column to the materials in the left hand column.

	Descriptions	Materials
___ 19.	Motor oil.	a. Viscous.
___ 20.	Honey.	b. Oily.
___ 21.	Light oil.	c. Both viscous and oily.

SPECIAL INSTRUCTIONS FOR EXERCISES 22 THROUGH 245. Organs can be visualized better with the use of contrast media. Match the contrast medium in the right hand column to the organs in the left hand column for which it would be primarily be used.

	Contrast Medium	Organs
___ 22.	Cholografin.	a. Urinary tract.
___ 23.	Hypaque M 75 percent.	b. Biliary tract.
___ 24.	Hypaque 50 percent.	c. Heart and great vessels.

Check Your Answers on Next Page

SOLUTION TO EXERCISES: LESSON 1

1. c (para 1-21a)
2. a (para 1-21b)
3. d (para 1-21c)
4. a (para 1-22a(1))
5. c (para 1-22a(2))
6. a (para 1-22b)
7. d (para 1-22c)
8. b (para 1-23a)
9. c (para 1-23b(2))
10. d (para 1-23b(3))
11. b (para 1-23c)
12. b (para 1-25b)
13. c (para 1-25b)
14. d (para 1-26a)
15. b (para 1-26b(2))
16. d (para 1-26c)
17. e (para 1-27a)
18. b (para 1-27a(3) Caution)
19. c (para 1-24b)
20. a (para 1-24b)

21. b (para 1-24b)

22. b (para 1-22c(2))

23. c (para 1-23b(3))

24. a (para 1-23b(2))

End of Lesson 1

LESSON ASSIGNMENT

LESSON 2	Digestive and Urogenital Systems
TEXT ASSIGNMENT	Paragraph 2-1 through 2-24.
LESSON OBJECTIVES	After completing this lesson, you should be able to select correct answers to questions about: Radiographic and fluoroscopic procedures involving the gastrointestinal tract and its auxiliary organs. Radiographic and fluoroscopic procedures involving the urogenital organs.
SUGGESTION	After completing the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 2

DIGESTIVE AND UROGENITAL SYSTEMS

Section I. THE DIGESTIVE SYSTEM

2-1. GENERAL

Examination of the digestive system includes a number of different technical procedures in which various items of equipment and materials are used. The method used will vary in certain details, depending upon the desires of the radiologist. The various components of the digestive system are nearly always examined selectively; for example, the esophagus, the stomach, the duodenum, the colon, and the gallbladder. Examination of each of these parts often constitutes a procedure in itself. In the discussion that follows, each part is considered as a unit. Except under emergency conditions, each of these examinations requires a previous appointment.

2-2. THE ESOPHAGUS

The esophagus lies immediately posterior to the trachea. It penetrates the diaphragm and enters the stomach by way of the cardiac orifice. Consider the esophagus as being divided into three portions--cervical, thoracic, and abdominal. Each may use specific radiographic reference points. The cervical portion is located above the upper situs of the mediastinum. The thoracic portion is between the superior aspect of the mediastinum and the diaphragm. The abdominal portion is between the diaphragm and the stomach.

a. **Preparation of Patient and Scheduling.** The study of the esophagus usually entails the combined use of fluoroscopy and radiography. Therefore, for practical reasons, this examination should be scheduled. No special preparation of the patient is required other than that the stomach be fairly empty so that it can accommodate the contrast medium without undue discomfort.

b. **Preliminary Procedure.** Everything should be in complete readiness when the patient reports for the examination. This generally requires the following.

(1) A routine setup of the fluoroscopic and radiographic facilities should be accomplished. This includes checking the x-ray unit for correct factors and operational readiness, mounting the footrest or shoulder braces, and checking to make certain that the proper type and numbers of cassettes (including identification material) are readily available for spot-film exposures. Ensure the digital monitor, TV, or videotape is ready for use. At the start of each day, the above equipment should be tested to ensure readiness.

(2) Protective aprons and gloves should be laid out for the radiologist and other medical personnel.

(3) The contrast medium should be prepared in accordance with established routine or as prescribed by the radiologist. Some type of barium sulfate preparation is usually used, but if perforation is suspected, an alternate non-barium sulfate radiopaque should be substituted. A thin-water mixture usually contains the contrast medium and water in equal parts by volume. A thick-paste mixture usually contains about six parts contrast medium to one part water. A drinking tube or a spoon should be on hand to administer the mixture to the patient while he is in the recumbent position.

c. **Fluoroscopic Examination.**

(1) Upon reporting, the patient is dressed in a suitable gown.

(2) The examination procedure should be explained to the patient so that he can cooperate.

(3) The patient is instructed (or assisted, if necessary) to take a position between the table and the fluoroscopic apparatus. Whenever possible, the fluoroscopic examination is started with the patient in the erect position.

(4) A preliminary screening of the area to be investigated is usually made by the radiologist.

(5) At a given signal from the radiologist, the specialist hands the patient a spoonful (or disposable cup, if a thin mixture is called for) of the previously prepared contrast medium. If the patient is in the erect position, the specialist should show him how to hold the cup so that it will not interfere with the free up-and-down movements of the fluoroscopic apparatus. This phase of the procedure is illustrated in figure 2-1.

(6) The patient ingests the contrast medium and controls his respiration as directed by the radiologist. The passage and behavior of the contrast medium is observed fluoroscopically and recorded using spot, cine, or other recording media.

Figure 2-1. Patient in position for fluoroscopic examination.

d. **Radiographic Examination.**

(1) Radiographs are made as requested by the radiologist or according to clinical routine. An RAO (right anterior oblique) is almost always included. Other radiographs may consist of AP (anterior-posterior) and lateral projections. The radiographs may be made with the patient in either the erect or recumbent position. See figure 2-1. In addition, the table may be tilted in the modified Trendelenburg position. In the case of large, heavy patients, the use of grid techniques should be considered.

(2) As soon as the patient is positioned, he is given a spoonful of the paste (contrast medium) and told to retain it in his mouth. Here, a definite sequence of steps is followed.

(a) The patient is instructed to swallow the contrast medium at a given signal and suspend respiration.

(b) Respiration is suspended for about 3 seconds to allow the contrast medium to distribute through the esophagus (this time interval will vary with clinical considerations).

(c) The exposure is taken.

(3) The following information applies to an RAO of the esophagus. See figures 2-2 and 2-3.

(a) Anatomical. Esophagus.

(b) Film. 14 x 17-inch, lengthwise.

(c) Position. Patient upright or recumbent, rotated 40º, right-hand palm out on hip, left hand resting on film support. Coronal plane through acromial processes 4 inches below upper edge of film holder (plane is taken with arms down).

(d) CR (central ray). Directed to the center of the film.

(e) Precautions. Respiration suspended in forced inspiration. Exposure is made during ingestion of contrast medium.

(f) Variations. For study of mucosal pattern of lower esophagus, use modified Trendelenburg position (head lowered-feet elevated). This is used in many clinics with the PA and lateral projections for the basic study of the esophagus.

(4) See figures 2-4 A, B, C and 2-5 A, B, C. These will provide examples of the AP and lateral esophagus.

THE ORDER OF PROCEDURE ESOPHAGUS, RIGHT ANTERIOR OBLIQUE
1. **Stuctures best shown.** Esophagus between the vertebral column and heart.
2. **Remove artifacts.** All clothing removed, including undergarments. Remove jewelry in areas of interst.
3. **Technical Factors:** 14 x 17 in. (35 x 43cm), (LW), Bucky. **LM:** Corresponding side.
4. **Patient/Part position:** a. Recumbent or erect. b. Recumbent preferred because of more filling of esophagus (due to gravity factor with erect). c. Rotate 35-40 degrees from a PA with the right anterior body against film holder or table. d. Right arm down; left arm flexed at elbow and by the patient's head. e. Flex left knee, if recumbent. f. Align mid oblique thorax to center of table with top of cassette 2 inches above level of acromion process.
5. **Collumination:** Use collumination (CF) 10 x 17 LW.
6. **CR:** Perpendicular to the film holder.
7. **SID:** 40 " to the bucky.
8. **Shielding:** Place lead shiel over the patient's pelvic region to shield gonads.
9. **Respiration:** Suspended respiration while drinking barium.

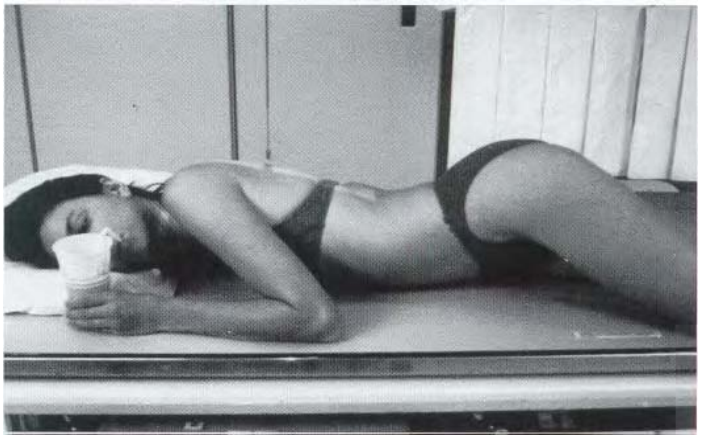


Figure 2-2. Esophagus, right anterior oblique.

SUGGESTED STARTING TECHNIQUE FOR RAO

HOLDER	CM	KVP*	MAS**	SID	GRID	CONE
Cassette	22-28	90	20	40"	8:1	10x17
Cassette	22-28	85	10	72º	No	LW

Figure 2-3. Radiograph of esophagus, RAO.

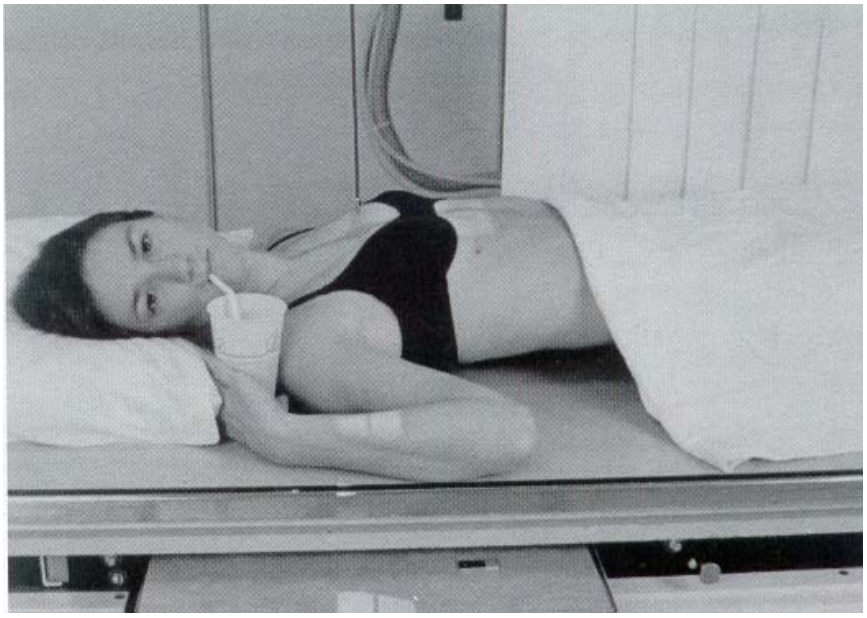


Figure 2-4 A. Positioning of AP esopghagus.

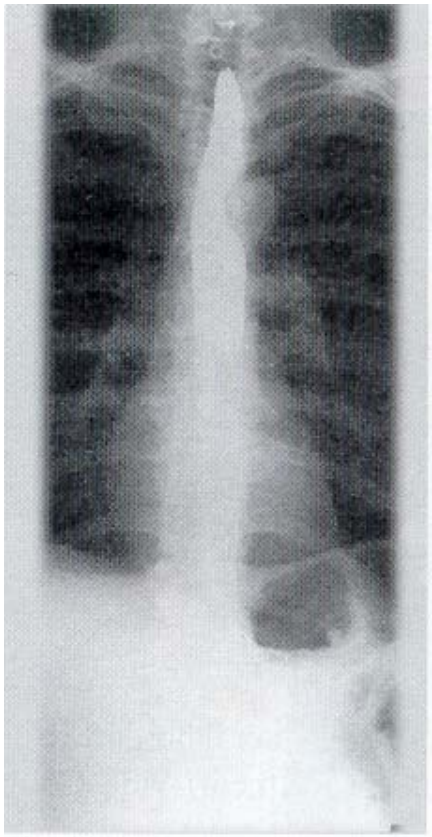


Figure 2-4 B. Radiograph.

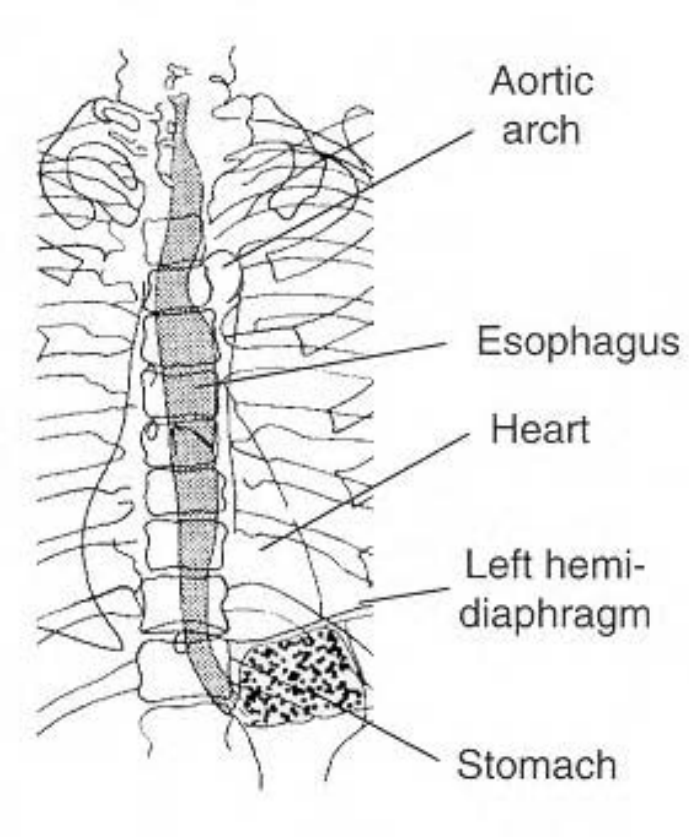


Figure 2-4 C. Diagram.

Figure 2-4. AP esophagus.

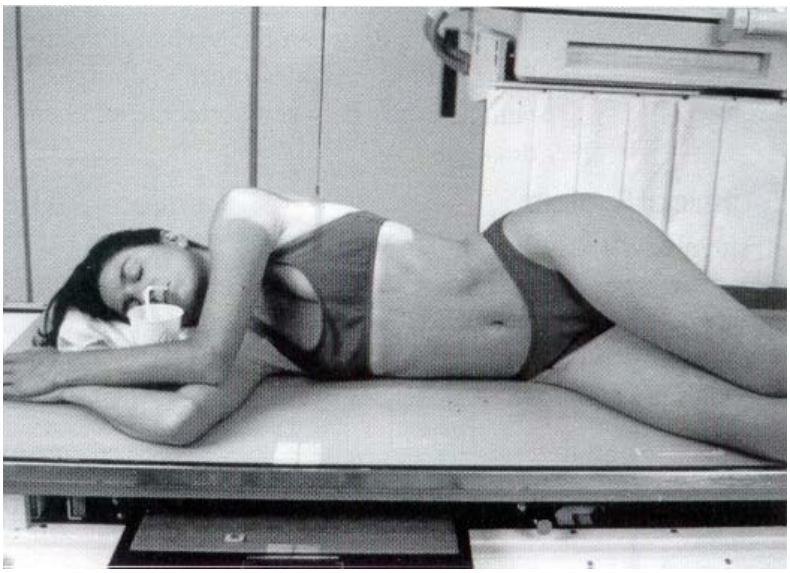


Figure 2-5 A. Positioning of lateral esophagus.

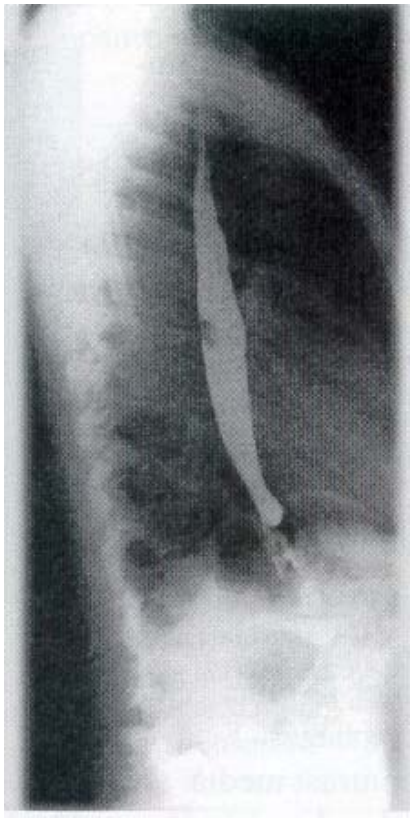


Figure 2-5 B. Radiograph.

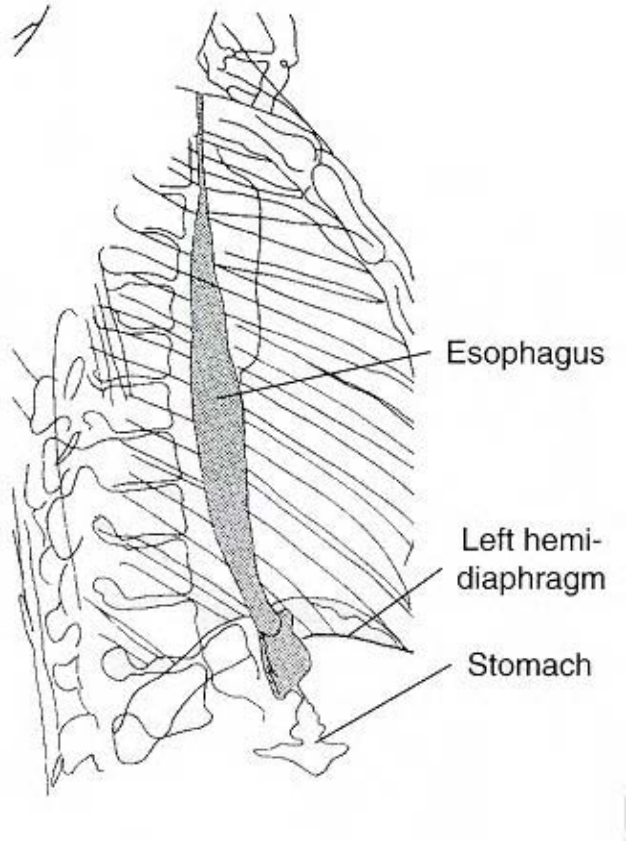


Figure 2-5 C. Diagram.

Figure 2-5. Lateral esophagus.

2-3. THE STOMACH AND DUODENUM (UPPER GI SERIES)

The position of the stomach varies with the amount of contents, type of body habitus, mutual pressure of adjacent organs, pathological condition, respiration, emotional state, and whether the subject is in the erect or recumbent position. The position of the duodenum varies in much the same way.

a. **Preparation of Patient and Scheduling.** Except in emergencies or under very unusual circumstances, examinations of the stomach and intestines should be scheduled. All appointments (including cancellations) should be logged in an appointment book or entered in an appropriate calendar chart.

(1) Inpatients. The appointment for the examination is made upon receipt of a properly prepared request form from the ward (also called nursing unit). Ward personnel generally prepare the patient for the examination, usually as prescribed by the operating procedures of the installation. In general, the preparation of ingredients is as follows.

(a) The patient will not be given a laxative within 24 hours of the examination.

(b) The patient should have nothing by mouth for a period of 8-12 hours prior to the time of the examination.

(c) The patient is not to drink or eat anything other than the barium mixture he receives in the x-ray department.

(2) Outpatients. The procedure is the same as that for inpatients, except that the outpatient is carefully instructed by the x-ray department as to what he must do to prepare for the examination (or is given a prepared form containing the necessary information).

b. **Preliminary Procedure.**

(1) A routine setup of the fluoroscopic and radiographic facilities should be accomplished.

(a) Single-unit setup. In this plan, a single x-ray unit (radiographic-fluoroscopic) is used for both phases of the examination. When fluoroscopy is completed, the unit is "switched over" and radiography is done.

(b) Single-unit, supplemented setup. The operational aspect of this plan is similar to the single-unit setup, except that the radiography is done on a separate x-ray unit located in another room (usually by another x-ray specialist). This plan permits the continuation of fluoroscopy with the same unit from one examination to the next and also expedites the handling and processing of exposed films.

(c) Double-unit setup. Two x-ray units (radiographic-fluoroscopic), located in adjacent rooms, are used. The personnel consist of the radiologist and one, or preferably two, x-ray specialists. Upon completion of fluoroscopy (including spot-film radiography, if indicated), the x-ray unit is changed over and radiography is done. While radiography is being performed on one patient, the examiner may step into the adjacent room and start the fluoroscopic examination of another patient. This process continues, back and forth, until the last examination is completed. The use of the double-unit setup saves excess handling of litter patients, is time saving, and simplifies working conditions.

(2) Contrast medium should be prepared in accordance with the established routine as prescribed by the radiologist. Eight to 16 ounces total volume per patient is usually required during fluoroscopic filling. If perforation is suspected, barium is inappropriate and an iodine medium should be substituted.

(3) Protective aprons and gloves should be laid out for the radiologist and other interested medical personnel.

(4) The radiographic request form containing pertinent information regarding the patient's case should be available to the radiologist at all times.

c. **Fluoroscopic Examination.**

(1) Upon reporting, the patient is dressed in a suitable gown.

(2) The examination procedure should be explained to the patient so that maximum cooperation may be attained.

(3) The patient is directed, or assisted, to take a position between the table and the fluoroscopic apparatus.

(4) A preliminary screening of the area under consideration is usually made by the radiologist. The radiologist may request a scout film if the patient’s history indicates prior surgery or recent examinations.

(5) At a given signal from the radiologist, the specialist hands the patient a cup of the contrast medium. Just before doing this, he should again stir the mixture.

(6) The examination proceeds as the patient ingests the contrast medium and controls his respiration as directed by the radiologist.

(7) The radiologist records the fluoroscopic images as necessary.

(8) In some instances, the radiologist will maneuver the patient through various positions under the fluoroscope in order to determine the degree of body angulation and the centering point of the CR for subsequent radiography. This may entail marking the CR-centering site on the body with a skin-marking pencil or measuring the patient on one side to determine the distance that the anterior superior iliac spine (ASIS) should be elevated above the table top during the exposure or both. The radiologist then conveys this information to the specialist, and the required exposures are made.

d. **Radiographic Examination.** The specialist will expose the radiographs according to clinical routine. At times, the radiologist may deviate from the established routine, depending upon his fluoroscopic findings. Figures 2-6 through 2-10 show three common projections.

(1) Figures 2-6 and 2-7, PA stomach and the diagram, demonstrate the structures of the stomach and the duodenum.

(a) Anatomical. Stomach and portions of duodenum.

(b) Film. 14 x 17-inch film.

(c) Position. The patient is prone, with median plan perpendicular to the center line of the table. Iliac crests are 5 inches below the center of the film, or as indicated at the time of fluoroscopy. Nonopaque pads may be used under the chest and thighs.

(d) Central Ray. Align to center of the film.

(e) Respiration. Suspended expiration.

(f) Collimation. Full film collimation recommended.

THE ORDER OF PROCEDURE THE STOMACH AND DUODENUM, PA	
1. **Structure best shown.** Stomach and duodenum with barium in the body and pylorus of stomach.	
2. **Remove artifacts.** All clothing removed, excluding underpants. Remove jewelry in area of interest.	
3. **Technical Factors:** 14 x 17 in. (35x43cm), (LW), Bucky.	**LM:** Corresponding side.
4. **Patient/Part position:** Patient prone with arms up beside head, provide pillow. a. Align midsagittal plane to table. b. Insure there is no body rotation.	
5. **CR:** a. Perpendicular to the film holder. b. Iliac crests 5 inches below center of film.	
6. **Collimation:** Use Full Film Collimation.	
7. **SID:** 40-44” to the Bucky.	
8. **Shielding:** Place lead shield over patient’s pelvic region to shield gonads.	
9. **Respiration:** Suspended expiration.	

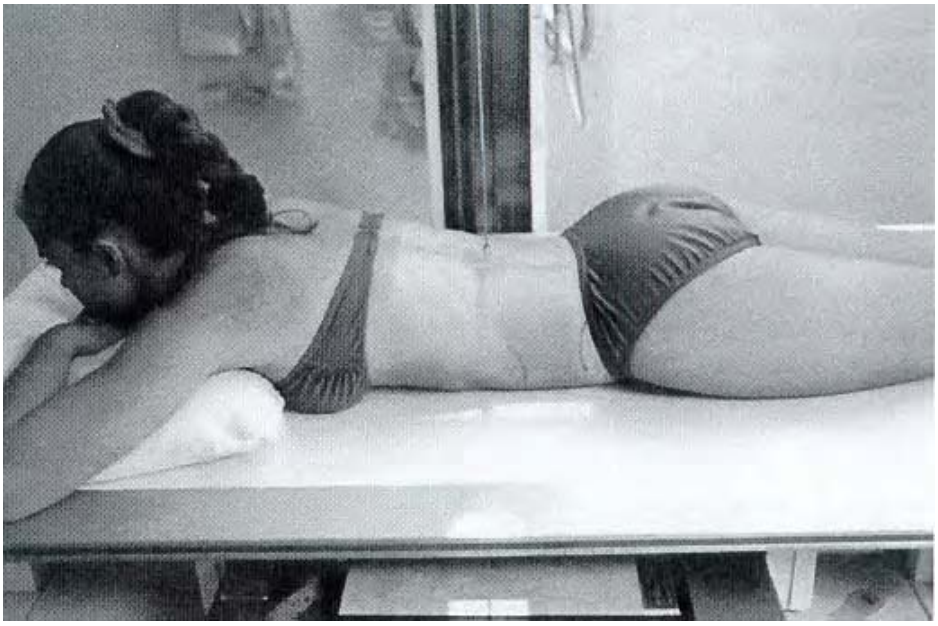
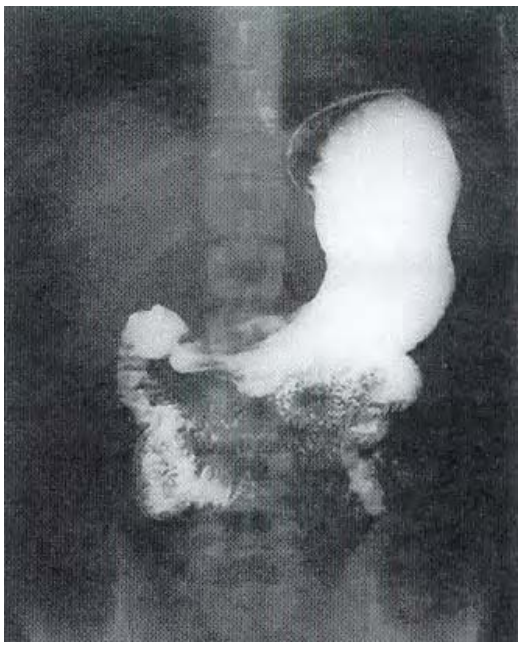


Figure 2-6. Stomach and duodenum, PA.

SUGGESTED STARTING TECHNIQUE

HOLDER	CM	KVP*	MAS**	SID	GRID	CONE
Cassette	18-22	90	30	40"	8:1	Film coverage



Radiograph of PA

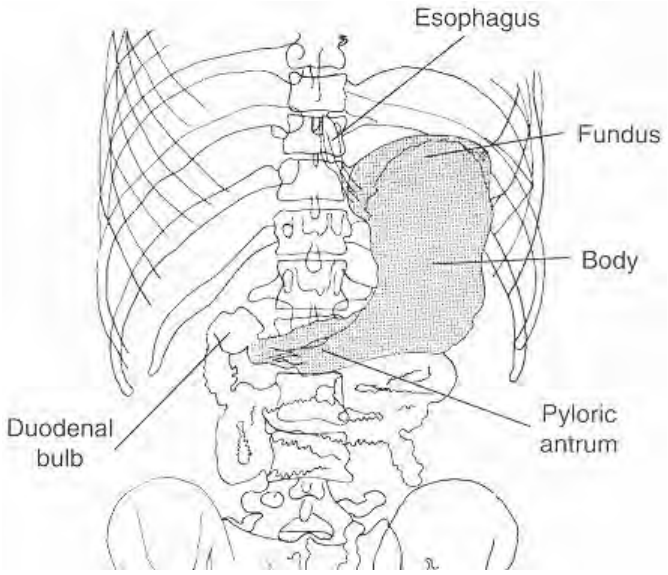


Diagram of the stomach

Figure 2-7, Radiograph of PA (left) and diagram (right) of the stomach demonstrate the parts of the duodenum.

(2) Figure 2-8 and 2-9: stomach and duodenum, RAO.

(a) Anatomical. Stomach and parts of the duodenum.

(b) Film. 10 x 12-inch lengthwise.

(c) Position. Body rotated 40º to 70º midpoint between vertebral column and lateral aspect of the body placed over center of table. Iliac crests at level of the lower film border.

(d) CR-UP. Align to the skin marking made surfing fluoroscopy and to the center of the film.

(e) Precaution. Suspended respiration.

(f) Additional. Grid.

(g) Variation. For suspected diaphragmatic hernia, tilt the patient 15º head down and make an exposure with suspended inspiration.

THE ORDER OF PROCEDURE STOMACH, RIGHT ANTERIOR OBLIQUE	
1. **Structure best shown.** Stomach and C-loop of duodenum. A profile image of the duodenum bulb.	
2. **Remove artifacts.** All clothing removed, excluding underpants. Remove jewelry in area of interest.	
3. **Technical Factors:** 10 x 12 in. (24 x 30 cm), (LW), Bucky.	**LM:** Corresponding side.
4. **Patient/Part position:** Recumbent with the body partially rotated into RAO position, provide pillow for head. a. From a prone position rotate 45 degrees with right anterior body against the film holder or table. b. Right arm down; left arm flexed at elbow and by the patient's head. c. Flex left knee if recumbent. d. Align mid-oblique thorax to center of table with top of cassette 2 inches above level of acromion process.	
5. **CR:** Perpendicular to the film holder. Average body type – CR midway between spinous process and lateral border of abdomen to the center of the cassette.	
6. **Collimation:** Use Full Film Collimation.	
7. **SID:** 40-44" to the bucky.	
8. **Shielding:** Place lead shield over patient's pelvic region to shield gonads.	
9. **Respiration:** Suspended expiration.	

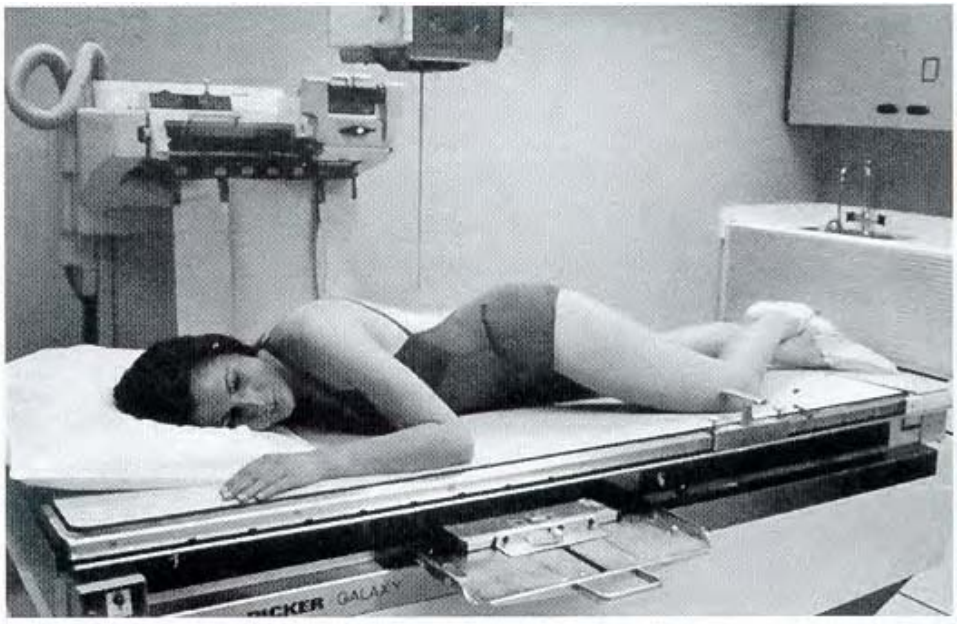
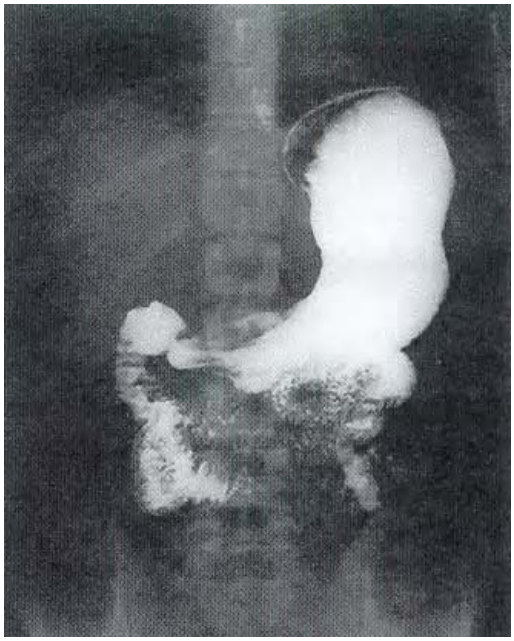


Figure 2-8. Positioning for stomach and duodenum, right anterior oblique.

SUGGESTED STARTING TECHNIQUE

HOLDER	CM	KVP*	MAS**	SID	GRID	CONE
Cassette	18-22	90	30	40º	8:1	Film coverage



Radiograph of stomach and duodenum.

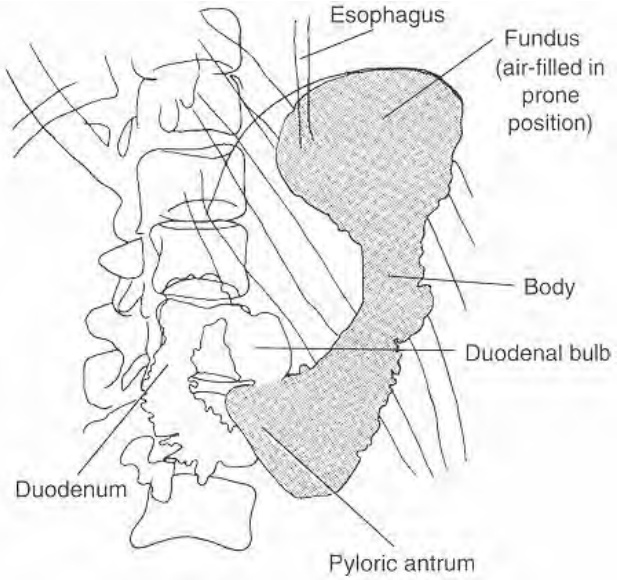


Diagram of stomach and duodenum.

Figure 2-9. Radiograph and diagram of stomach and duodenum, RAO.

(3) Figures 2-10 and 2-11, lateral stomach, demonstrate the structures of the stomach and the duodenum.

(a) Anatomical. Stomach and portions of duodenum.

(b) Film. 10 x 12-inch film.

(c) Position. The patient is recumbent in a right lateral position with coronal plain perpendicular to the centerline of the table. The bottom of the film is at the iliac crests. Nonopaque pads may be used under the chest and thighs.

(d) Central Ray. Align to center of the film.

(e) Respiration. Suspended expiration.

(f) Collimation. Full film collimation recommended.

Figure 2-10. Positioning for lateral stomach and duodenum.

Radiograph of stomach and duodenum.

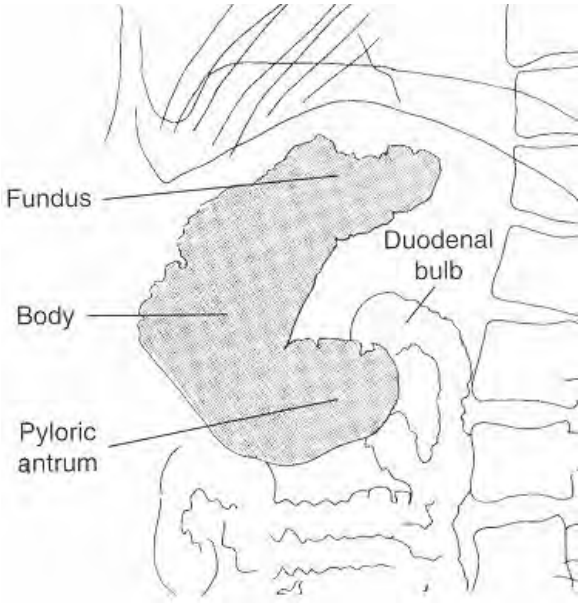


Diagram of stomach and duodenum.

Figure 2-11. Radiograph and diagram of stomach and duodenum, lateral stomach.

2-4. SMALL INTESTINE (SMALL BOWEL SERIES)

In the investigation of the small intestine, the study is usually done by a combination of fluoroscopic and radiographic methods. The preparation of the patient, contrast medium, and management of the facilities are essentially the same as for the examination of the stomach. The radiologist may direct that ice-cold normal saline solution (cold isotonic method) be used as the vehicle for the barium sulfate in place of water, to speed up the examination. The cold solution stimulates peristalsis, causing the barium to pass more rapidly through the gastrointestinal tract. In the double method, a designated quantity of contrast medium is administered to the patient at a specified time prior to fluoroscopy; during fluoroscopy, additional barium is given to the patient (spot-filming may also be done at the time). Radiographs are made at the discretion of the radiologist: for example, a film every 15 minutes for the first hour, then at half-hour intervals, as indicated. Appropriate identification markers should be used for each exposure to indicate the time intervals.

2-5. LARGE INTESTINE (DOUBLE CONTRAST) BARIUM ENEMA

a. A method that is widely used for the introduction of the contrast media into the colon is based on a double contrast consisting of barium and air. The liquid component of the contrast media is introduced into the colon by means of gravity. Once the barium has coated the lining of the colon, the barium is mostly drained out of the colon before air is administered. Using the Air-Contrast enema tip and inflator bulb (figure 2-12), air is slowly pumped into the colon either by the radiologist or per his instructions.

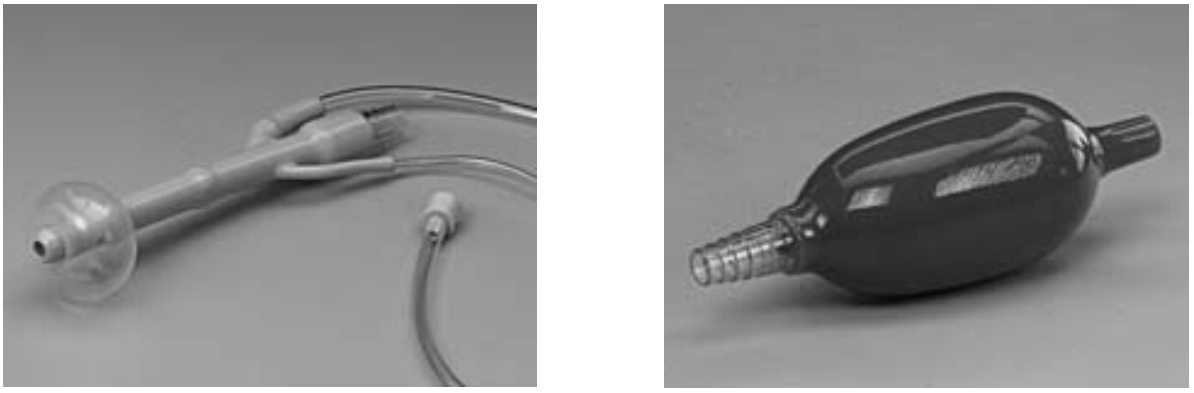


Figure 2-12. The rectal tip with catheters for inflation of a retention balloon and an inflator bulb used to inflate the balloon and administer air for double-contrast examinations.

(1) The liquid contrast is now introduced into the colon (under fluoroscopic control) via the disposable enema kit--bag, tubing, and tip--using a gravity to allow the flow of barium.

(2) The amount and rate of the flow of the contrast medium into the colon is controlled by means of a clamp on the outlet tubing or by pinching the tubing between the fingers.

(3) Posturing of the patient, fluoroscopy, palpation, spot-filming, and radiography are carried out according to the established procedures or the particular needs of the case.

(4) When administering air into the colon for double-contrast studies, the procedure is as follows.

(a) The outlet tubing is clamped off.

(b) The inflator bulb is pumped until the desired amount of air has been administered to the colon (this is determined by the radiologist).

(c) Subsequent steps of the examination are carried out according to established procedure.

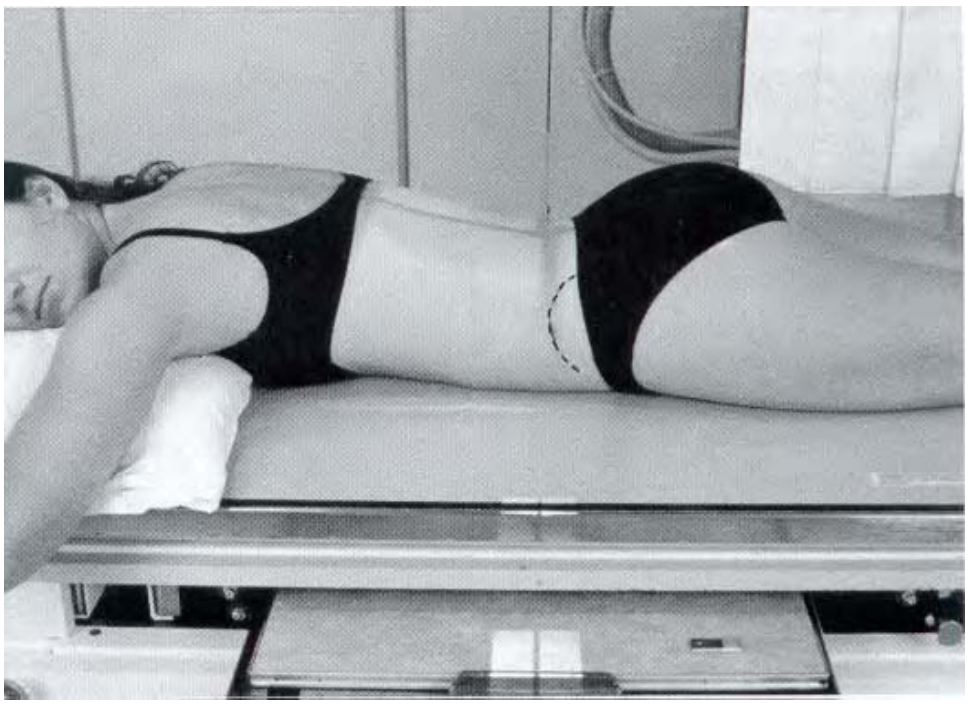


Figure 2-13. Large bowel, PA (double-contrast study, post-evacuation view).

SUGGESTED STARTING TECHNIQUE

HOLDER	*CM	KVP	MAS	SID	GRID	CONE
Cassette	18-22	90	20	40"	8:1	Film coverage

HIGH KILOVOLTAGE TECHNIQUE

HOLDER	CM	KVP	MAS	SID	GRID	CONE
Cassette	18-22	125	10	40"	8:1	Film coverage

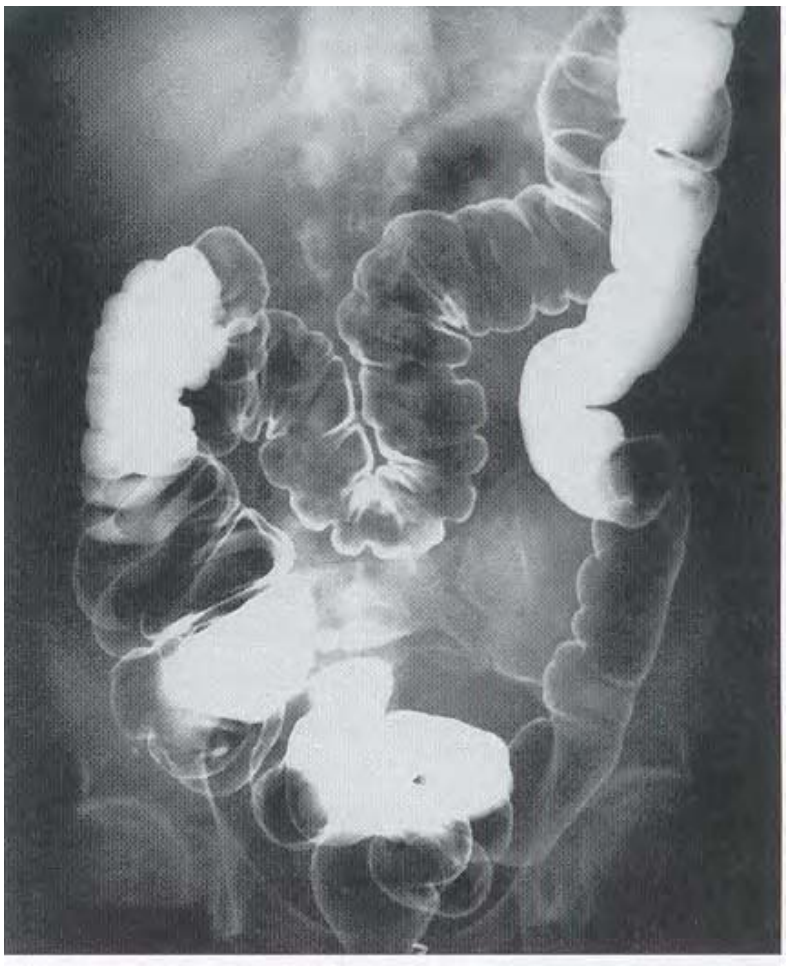


Figure 2-14. Radiograph of the large bowel, PA or AP with double contrast.

b. In another method (referred to as the "single-stage method"), the air is introduced into the colon at the instant the column of the radiopaque contrast material has advanced to predetermined area in the colon.

(1) After patient preparation, ready the necessary facilities for the examination. With the patient in the prone position on the x-ray tilt-table, the radiologist observes the advance of the radiopaque column of contrast material in the colon. This is done under fluoroscopic control. The barium suspension is allowed to run slowly. When the head of the column reaches the splenic flexure, the flow is immediately stopped.

(2) The x-ray table is then tilted to the Trendelenburg or modified Trendelenburg position and the patient is rotated to the left.

(3) Insufflation of air is begun. The transport of the barium-suspension column is studied fluoroscopically as the air pushes it onward in the colon. The patient is now rolled onto his back and turned to the right as far as directed by the radiologist. This maneuver allows the barium suspension to flow toward the hepatic fissure and enter the ascending and cecal portions of the colon. Spot-films are made as indicated. Usually, as the contrast medium reaches the hepatic fissure, the air input is closely controlled and the tilt-table may be brought to the horizontal or the head-end may be slightly elevated to permit filling of the cecum. Further distribution of the contrast material in the colon is carried out (under fluoroscopic control) by rotating the patient, when necessary, as much as 360º in either direction.

(4) After completion of the fluoroscopic phase of the examination, the outlet tubing is clamped off and radiography is done according to established procedure. This procedure may be performed as follows.

(a) PA and AP (anterior-posterior) projections are made using a vertical CR with the patient in the horizontal position.

(b) PA or AP projections are usually made with the patient in the right and left lateral decubitus positions using a horizontal CR.

(c) For optimum results, a minimum of 90 kVp (kilovolt peak) (based on 8 to 1 Potter-Bucky diaphragm) should be used. Grid-front cassettes may be found extremely useful for making the exposure with the patient in the lateral decubitus positions.

(d) The AP axial projection is sometimes done during single contrast studies using a 30-40 degree tube angle. It is made according to established procedures.

(e) Other projections include the lateral rectum, sometimes done cross-table with the patient in the prone position, during double contrast examinations. Ensure the central ray is horizontal perpendicular. Posterior oblique projections are also done during single contrast examinations. All projections are done according to established procedures.

(f) After necessary radiography has been completed, the rectal tube is withdrawn and the patient is sent to the toilet.

c. Another variation of technique is based on the use of a relatively high kVp. Due to the greater penetration of such radiation, it is possible to visualize the intraluminal as well as the circumjacent aspects of the colon. For example, sessile or pedunculated growths, such as polypoid lesions, can be shown just as cholesterol stones are demonstrated within the radiopacified bile in the gallbladder. In general, this method is carried out as follows.

(1) Patient preparation is usually the same as for the previously described methods, unless the radiologist prescribes otherwise.

(2) The barium sulfate suspension is prepared in the ratio of one part of barium sulfate powder with four to six parts of water by volume, depending upon the preferences of the radiologist and the nature of the particular case under consideration.

(3) The barium sulfate suspension is introduced into the colon by gravity. This introduction of the medium is always done under fluoroscopic control.

(4) Spot-filming may be carried out by conventional technique or by a relatively high-kilovoltage technique, using from 120 to 140 kVp.

(5) Radiography is done after completion of the fluoroscopic part of the examination and before evacuation. The prescribed projections are made with the patient postured according to the instructions of the radiologist.

(6) After completion of radiography, the patient is allowed to evacuate, and post-evacuation radiographs are made, if required.

2-6. LARGE INTESTINE (SINGLE CONTRAST) BARIUM ENEMA

a. **Routine Views of the Barium Enema.**

(1) PA or AP.

(2) RAO and LAO (or RPO and LPO).

(3) Lateral rectum, taken as a cross table ventral lateral decubitus for double contrast exam.

(4) AP axial (butterfly position).

(5) Bilateral decubitus, taken as part of the double contrast exam.

b. **Preparation of Patient and Scheduling.**

(1) Inpatient. Ordinarily, the x-ray department in cooperation with the referring ward accomplishes scheduling. The x-ray department makes the appointment for a special date and time upon receipt of a properly prepared request form from the ward. Ward personnel generally prepare the patient for the examination. Normally, the patient is given a cathartic about 8 to 12 hours before the examination, with the approval of the patient's physician. A laxative is prescribed for the patient in conjunction with a cleansing enema. A simple cleansing enema may be given to the patient about an hour before the examination. In most cases, breakfast is withheld. However, a light breakfast is sometimes allowed.

(2) Outpatient. This procedure is essentially the same as for the inpatient. When the appointment is made, the outpatient is given instructions as to pre-examination preparation. Arrangements should be made with a ward or nearby dispensary to provide facilities for the cleansing enema if the patient has no means for accomplishing this himself.

c. **Preliminary Procedure.**

(1) A routine setup of the fluoroscopic and radiographic facilities should be accomplished.

(2) Contrast medium should be prepared in accordance with established routine or as prescribed by the radiologist. (Note: It is imperative that the specialist made certain that the contrast mixture is prepared exactly as prescribed. The type of examination, single-contrast or double-contrast, will determine the thickness of the suspension.) The contrast medium must be worked into a thoroughly mixed suspension using either an electro-mechanical device or the spoon or paddle method.

(a) Step 1. Fill the container with water to about half full. Ordinarily, the water should approximate normal body temperature.

(b) Step 2. Add the correct amount of barium, and mix into a homogenous suspension.

(3) The following accessory items are required to administer the contrast medium.

NOTE: The type of examination, single-contrast or double-contrast, determines the number of the particular items that will be used.)

(a) Enema (irrigator) bag, 2-quart; an apparatus of special designed which actuates the flow of the barium suspension through the tubing by means of gravity.

(b) Many medical facilities now use disposable enema bags, tubing, and tips. These are complete disposable units that minimize the chance of transmitting a disease organism from one patient to another. Disposable enema bags are perhaps the most convenient to use of all the barium enema equipment. Most of them come with the barium powder already in the bag. To mix, water is added and the bag is shaken vigorously. Cleanup after the examination is virtually eliminated since the entire kit is discarded after use. Disposable enema kits are illustrated in figure 2-15.

Figure 2-15 A. Disposable enema kit.

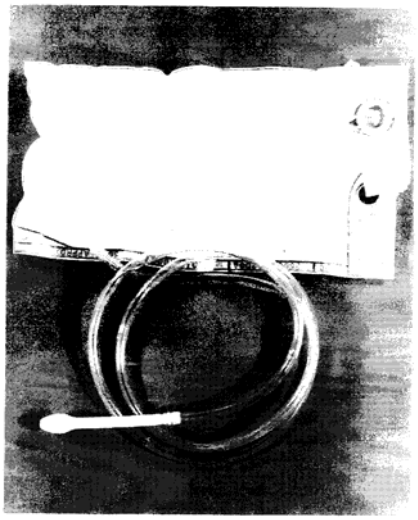


Figure 2-15 B. Disposable single contrast enema kit.

Figure 2-15. Disposable enema kits.

(c) A suitable support for the enema bag. A conventional irrigator (IV) stand may be used. The top of the enema bag should be at an elevation of about 3 feet above the top of the x-ray table.

(d) A supply of contamination and latex rubber-free rectal tips--one per patient for each examination session. Disposable rectal tips should be used, whenever possible.

(e) Catheter, rectal, air contrast safety end flexible silicone enema tip with retention cuff with an inflating bulb (Multi-Puff Insufflator) that fits the tubing and has a self-contained anti-reflux valve (figure 2-12).

(f) KY jelly.

(g) Paper napkins and hand towels.

(4) All of the apparatus must be clean and free of contamination before use. "Rubber goods," such as catheters, tubing, and rectal tips, must be kept aseptic prior to use.

(5) Rectal tips should be lubricated with KY jelly or a similar substance. To ensure cleanliness, the lubricated tips should be covered with nonabsorbent paper.

(6) A disposable enema bag with tubing attached should be filled with the required amount of contrast medium and placed on a suitable stand, usually near the foot of the x-ray table.

(7) When separate toilet facilities are not provided for patients, special provisions should be made to that patients undergoing barium enema examinations have unhampered access to the toilet. Bedpans should be provided for patients who are unable to use the toilet.

(8) Protective aprons and gloves should be laid out for the radiologist and other interested medical personnel.

d. **Fluoroscopic Examination.**

(1) When the patient arrives for their examination, have the patient dress in a suitable gown.

(2) The examination procedure should be explained to the patient so that maximum cooperation may be attained. At this stage notify the radiologist that the patient is ready.

(3) The radiologist will perform a preliminary screening of the area under consideration. This is usually done with the patient in the recumbent position.

(4) At a given signal from the radiologist, the specialist inserts the rectal tip into the patient's anus. Just before making the insertion, a small amount of contrast medium should be allowed to flow through the tube in order to squeeze out the residual air. The patient is rolled onto his side on the table with his knees flexed. The rectal tip is inserted into the anus with a steady, gradual pressure, exerted anteriorly. When the tip is passed beyond the anus, it should be directed forward at an angle in line with the umbilicus. Due to the extreme sensitivity of the rectal region, care must be exercised in making the insertion. In case a retention catheter is used, caution must be exercised not to distend the inflated bulb excessively. Whenever possible, allow the patient to insert the tip, himself. Be sure to provide appropriate instructions.

(5) Upon a signal from the radiologist, the specialist initiates the flow of the contrast mixture and fluoroscopic observation is made. The radiologist will signal the specialist when to interrupt and when to resume the flow of the contrast medium. It is imperative that the specialist respond instantly to these signals. Spot filming may also be done during this phase of the examination. As the patient is maneuvered for changes in position, the specialist should take care to see that the enema bag tubing does not become kinked or accidentally withdrawn. If the tube should become clogged, the obstruction can usually be moved by stripping or "milking" the tube in the direction of flow. If the radiologist desires the filling of the bowel to proceed at a slow rate, the specialist can control the rate of filling by lowering the enema bag or by pinching the tubing between the fingers. Upon completion of "filling" and fluoroscopy, the patient is cautioned to retain the contrast medium until radiography is accomplished. It may be advisable to leave the rectal tip in place until all radiographs are done. This sometimes prevents the patient from prematurely expelling the contrast medium.

e. **Radiographic Examination.**

(1) Regardless of the type of setup (single-unit; single-unit, supplemented; or double-unit), it is usually best to do radiography of the barium-filled colon by having the patient remain on the same x-ray table on which fluoroscopy was performed. This lessens the possibility of accidental evacuation. The required radiographs are made in accordance with established routine or as directed by the radiologist.

(2) For the single-contrast barium enema, a PA projection of the barium-filled colon (figures 2-16 and 2-17) is obtained. Details are as follows:

(a) Anatomical. Colon.

(b) Film. 14 x 17-inch, lengthwise.

(c) Position. Patient prone, level of iliac crests to the center of the film.

THE ORDER OF PROCEDURE BARIUM ENEMA, AP AND/PA	
1. **Structure best shown.** Entire contrast-filled large intestine. Both PA and AP are generally taken with double contrast study..	
2. **Remove artifacts.** All clothing removed, including undergarments. Remove jewelry in area of interest.	
3. **Technical Factors:** 14 x 17 in. (35x43 cm), (LW), Bucky. For larger patients, use several CW 14 x 17 in.	**LM:** Corresponding side.
4. **Patient/Part position:** Patient prone or supine, with arms up beside head, provide pillow. a. Align midsagittal plane to table. b. Insure there is no body rotation.	
5. **CR:** Perpendicular to the film holder. a. Iliac crests 5 inches center of film.	
6. **Collimation:** Full film coverage.	
7. **SID:** 40-44" to the Bucky.	
8. **Shielding:** Place lead shield over patient's pelvic region to shield gonads.	
9. **Respiration:** Suspended expiration.	

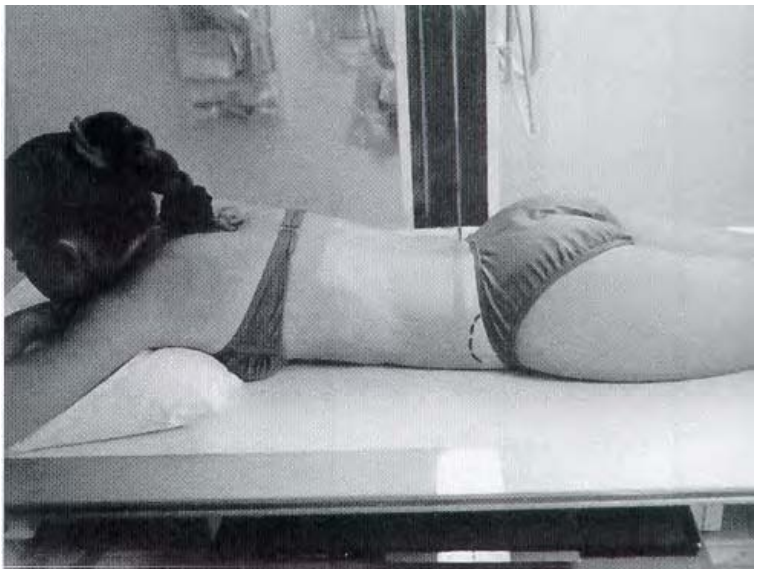


Figure 2-16. Large Intestine, barium enema, PA (pre-evacuation).

SUGGESTED STARTING TECHNIQUE

HOLDER	*CM	KVP*	MAS**	SID	GRID	CONE
Cassette	18-22	90	20	40"	8:1	Film coverage

*Measure through abdomen over 12th rib.

HIGH KILOVOLTAGE TECHNIQUE

HOLDER	CM	KVP*	MAS**	SID	GRID	CONE
Cassette	18-22	110-125	10	40"	8:1	Film coverage

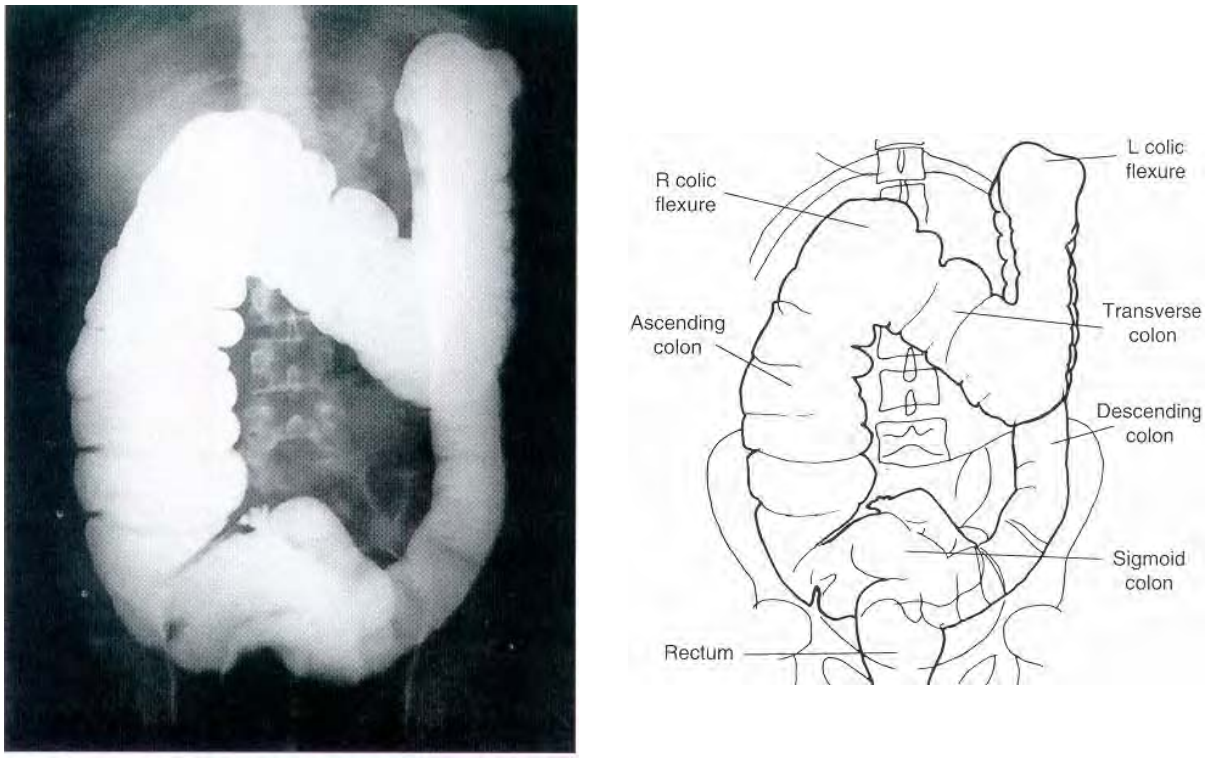


Figure 2-17. Radiograph and diagram of the large bowel, PA or AP with single contrast.

(d) CR. Align to center of the film.

(e) Precaution. Suspended respiration.

(f) Post-evacuation radiograph. After exposure, the patient is allowed to evacuate the enema. A post-evacuation PA projection is usually done using the same procedure as for the pre-evacuation PA.

(3) A special projection of the sigmoid colon (LPO) is sometimes done. Details are as follows:

(a) Anatomical. Sigmoid colon overlying the sacrum and left wing.

(b) Film. 14 x 17.

(c) Position. Patient supine. Left hip down, right hip and trunk rotated up to 30º to 60º (LPO-lateral posterior oblique) as indicated by fluoroscopy.

(d) CR. Align to center of film. Place area outlined fluoroscopically over the center of the film.

(e) Precaution. Suspended respiration.

(f) Additional. Grid.

(4) A special projection of the rectum (LAT) is also required at times (figures 2-18 and 2-19). Details are as follows:

(a) Anatomical. Rectal ampulla, rectum, sigmoid, and a portion of the descending colon.

(b) Film. 10 x 12-inch.

(c) Position. Patient is left lateral recumbent position. Knees partially flexed for support with a point 2 inches anterior post skin surface over the centerline of table to upper border of film.

(d) Align. CR to center of film.

(e) Precaution. Respiration suspended. Patient should be in true lateral position and will sometimes require buttressing.

(f) Additional. Grid.

(5) The double-contrast (air contrast) barium enema involves the simultaneous use of two types of contrast media--radiopaque in the form of residual barium adhering to the mucosa; and radiolucent, or air, which is introduced by means of an insufflator. In general, the procedure is as follows.

(a) Fluoroscopy and radiography are accomplished as for single-contrast study. That is, the patient is screened, the colon is filled with contrast medium, and exposures are made of the filled colon. The patient is then instructed to evacuate as rapidly as possible (20-30 seconds).

THE ORDER OF PROCEDURE BARIUM ENEMA, LATERAL RECTUM	
1. **Structure best shown.** Rectum and sigmoid colon anterior to the sacrum.	
2. **Remove artifacts.** All clothing removed, including undergarments. Remove jewelry in area of interest.	
3. **Technical Factors:** 10x12 in. (24x30 cm), (LW), Bucky. For larger patients, use several CW 14 x 17 in.	**LM:** Corresponding side.
4. **Patient/Part position:** a. Recumbent in true lateral position, work quickly. b. Center mid-axillary plane to centerline of table. c. Knees and hips partially flexed. d. Center patient and cassette to CR. **NOTE:** Ventral decub lat. rectum (Alternate projection with double contrast exam, this allows the air to fill the rectum), cross table.	
5. **CR:** Vertical Perpendicular to 1" distal to level of ASIS, centered to mid-axillary plane (midway between ASIS and posterior sacrum).	
6. **Collimation:** To outer film borders.	
7. **SID:** 40-44" to the Bucky.	
8. **Respiration:** Expose at full expiration.	

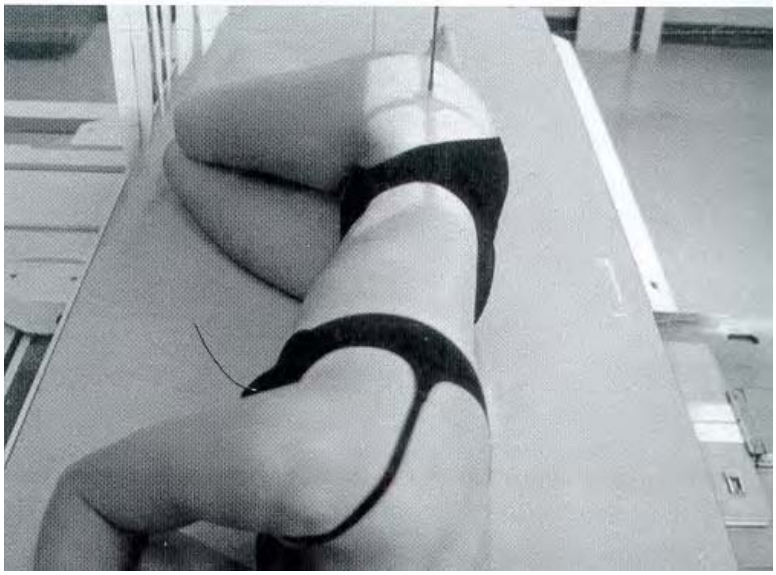


Figure 2-18. Lateral rectum, barium enema.

SUGGESTED STARTING TECHNIQUE

HOLDER	*CM	KVP*	MAS**	SID	GRID	CONE
Cassette	28-34	90	220	40º	8:1	Film coverage

* Measure through the plane of the iliac crests.

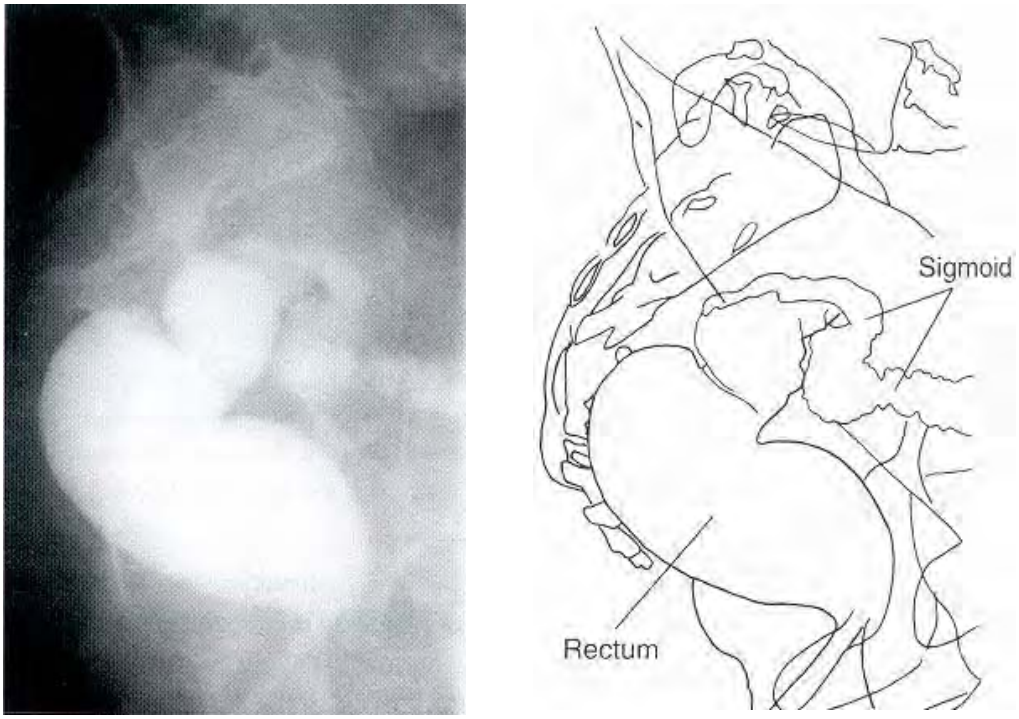


Figure 2-19. Radiograph of lateral rectum.

(b) Immediately after evacuation, the patient is recalled for fluoroscopy. Then, air is introduced into the colon by means of a colonic insufflator. This is done under fluoroscopic control.

(c) Routine radiographs are usually obtained in both the prone and supine positions, because the opaque medium may tend to collect and "puddle" due to the influence of gravity. Radiographs made with a horizontal CR and the patient in the right lateral decubitus position and the left lateral decubitus position are often obtained. Stereoscopic films may be made if indicated.

(d) The specialist must accomplish the necessary radiography as rapidly as possible since the retention of a considerable volume of air in the colon may cause distress to the patient.

(e) If a retention catheter is used, it should first be deflated and then withdrawn immediately upon completion of radiography to enable the patient to expel the air from the colon.

(f) Examination of the rectum is necessary during the barium enema in both the single and double contrast studies. Figure 2-19, demonstrates the Lateral Rectum in the single contrast study. During double contrast studies with air injected, the lateral rectum is viewed in the decubitus position with a ventral cross-table lateral projection.

(g) The patient is directed to a toilet and instructed to evacuate. After evacuation, a post-evacuation radiograph is made.

2-7. GALLBLADDER

a. **General.** Radiographic studies of the Gallbladder are rarely done. These studies have been replaced with other modalities such as ultrasound.

(1) Radiographic visualization of the gallbladder is done by cholecystography. Radiographic investigation of the biliary tract is by cholangiography. For these procedures, it is necessary to convey a contrast medium to the gallbladder along with the bile.

(2) Bile is manufactured by the polyhedral cells of the liver which extract the necessary constituents from the circulating blood. The gallbladder's ability to concentrate the bile makes it possible for a sufficient amount of the cholecystopaque to collect within the gallbladder to permit radiographic visualization. After oral administration, the contrast medium, if in pill form, disintegrates in the stomach.

(a) Most of the contrast medium is absorbed in the small bowel and conveyed to the liver via the portal vein.

(b) As the contrast medium moves throughout the liver, it becomes associated with the liver cells and is secreted with the bile.

(c) As the bile containing the contrast medium passes along the ducts, some of it is discharged into the duodenum and some of it backs up into the gallbladder where concentration occurs.

(d) The elimination of the contrast medium from the body is dependent upon various factors such as the type of contrast medium and the nature and degree of dysfunction related to the digestive system. Normally, some of the contrast medium is not absorbed, but is eliminated via the colon. The kidneys eliminate the part that is not removed from the blood as it passes through the liver.

(e) As the gallbladder discharges the bile containing the contrast medium into the small bowel after the ingestion of fatty meal, the medium is reabsorbed and conveyed to the liver and secreted again. This cycle continues until the contrast medium is completely eliminated from the body via the kidneys and colon.

b. **Preparation of Patient and Scheduling.** Patient preparation and scheduling are in accordance with the established clinical routine. In general, the preparation of the patient may be as follows.

(1) On the day before the examination (before ingestion of the contrast medium), a PA projection of the abdomen (11x14) may be done. This is a survey or scout film.

(2) The patient is not allowed to eat fats after the noon meal the day before the examination.

(3) About 12 hours prior to the examination, the patient ingests the contrast medium according to the manufacturer's instructions. Telepaque is usually used with the average dose being 6 tablets.

(4) After taking the pills, the patient should not be allowed to eat or drink anything until the time of the examination.

(5) To make certain that none of the contrast medium has been lost, the patient should be instructed to report any vomiting or bowel movements.

(6) If the initial films show no stones, the patient is given a fatty meal to promote good gallbladder contraction. An additional film is usually done 30 minutes to one hour after the fatty meal. Sometimes commercially prepared compounds or mixtures may be used in place of the fatty meal.

NOTE: Before giving a fatty meal, consult the radiologist. A fatty meal should not be given to patients if stones are seen in the initial films). This precaution is necessary because the "emptying" of the gallbladder caused by the fatty meal may release one or more stones into the biliary ducts causing obstruction.

(7) The procedure may vary since every radiologist has his preferred method. For example, some radiologists may request that the patient be given two teaspoonfuls of paregoric one-half hour after the ingestion of cholecystopaque or that an enema be administered one hour prior to radiography.

(8) For an examination of the biliary ducts (by the intravenous injection of Cholografin), the referring ward schedules and provides the preparation of the patient. Usually, the patient does not eat anything after 1800 hours on the day prior to the examination. On the morning of the examination, the patient is given a sensitivity test. If the test is negative and there are no contraindications, 20 to 40 cc of the cholecystopaque is injected intravenously by the radiologist. This examination is done in the operating room using sterile techniques.

2-8. CHOLECYSTOGRAPHY

Cholecystography is a radiographic procedure for the demonstration of the gallbladder after making the bile radiopaque by means of a contrast medium, which may be administered either orally or intravenously.

a. **Oral Method.**

(1) The patient is prepared in accordance with the prescribed pre-examination procedure.

(2) The contrast medium is administered according to prescribed procedures.

(3) Upon reporting to the x-ray department, the patient is dressed in a suitable gown. He should be questioned as to how he carried out each step of the pre-examination procedure and whether he experienced any vomiting or diarrhea. If any vomiting or diarrhea occurred, the x-ray specialist should report it to the radiologist.

(4) The number and type of projections made depends upon prescribed procedures and the suspected pathology. Usually, a survey film is made to determine the position of the gallbladder, the correctness of the exposure factors, the presence and extent of gas or unabsorbed contrast medium in the bowels, and evidence of outstanding pathology. Details of the scout film are described below and illustrated in figures 20 and 2-21.

(a) Anatomical. General localization of the gallbladder.

(b) Film. 14x17-inch film, and lengthwise. (Some radiologists prefer a 10x12-inch film.)

(c) Position. The patient is prone with arms alongside the body. He is positioned as for a PA abdomen exposure with the crest of the ilium 3 inches below the center of the film.

(d) CR. The CR is aligned to the center of the film.

(e) Precaution. Suspended expiration straight.

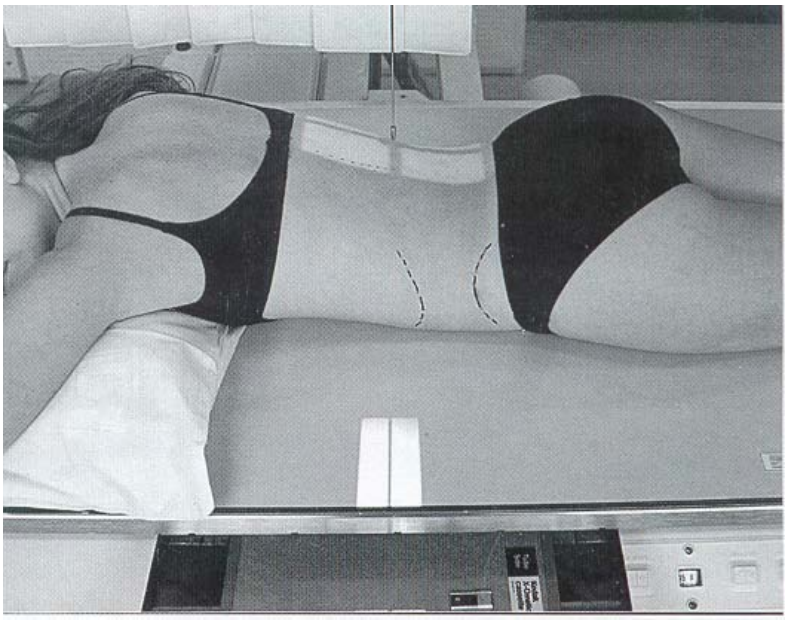


Figure 2-20. Gallbladder, PA Projection, “SCOUT”.

Figure 2-21. Radiograph of a gallbladder.

(5) Other films may include the following.

(a) PA prone projection using an 8 x 10-inch film and a tightly restricted cone field.

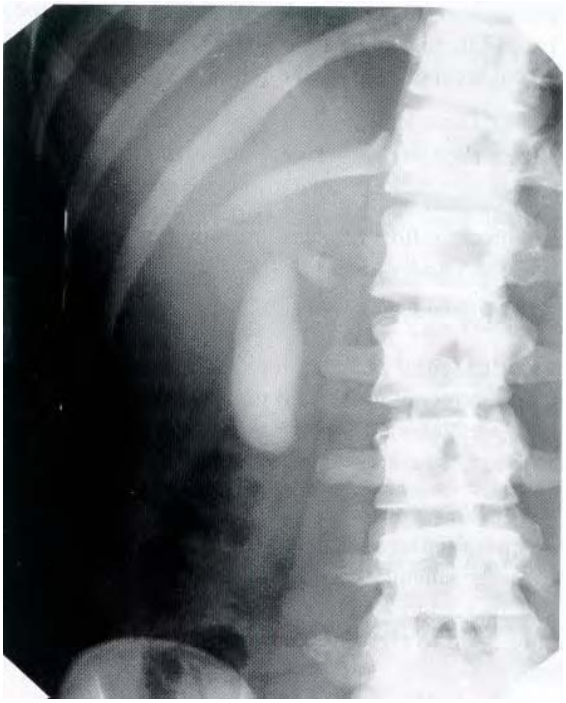
(b) LAO using a tightly restricted cone field (6 inches) and an 8 to 10-inch film. This radiograph may be done with the patient recumbent (figure 2-22) or erect. This position tends to displace the transverse processes of the vertebrae away from the gallbladder. The body is rotated 20º to 30º. The degree of body rotation necessary for optimum demonstration of the gallbladder varies according to body habitus and position; for example, thin subjects generally require greater rotation than stout subjects. Varying degrees of rotation may be necessary to differentiate gallstones from kidney stones or calcified bodies in the mesenteric structure.

(c) Right lateral projection with the patient in the recumbent position, utilizing an 8 by 10-inch film and a restricted cone field.

(d) PA projection with the patient on his right side (Kirklin) using an 8 by 10-inch film, restricted cone field, and vertical Bucky diaphragm or grid-cassette.

(e) RPO (right posterior oblique) using an 8-inch x 10-inch film and a restricted cone field. This radiograph may also be done with the patient in either the recumbent or erect position.

(6) Radiography of the gallbladder with the patient in the erect position may be done by the using essentially the same relationships with reference to part, film plane, and alignment of the CR. The erect position will cause the bile laden with cholecystopaque to stratify into fluid levels according to the degree of concentration and relative specific gravity. The gallstones, which are lighter than certain layers of the bile, will float and, upon floating together, form a "density layer" which renders them radiographically demonstrable. Small, but heavier-than-bile, stones will tend to gravitate to, and collect in, the fundus portion of the gallbladder. In addition, the gallbladder tends to shift downward, backward, and towards the midline. Therefore, when the patient is first x-rayed in the recumbent position and then in the erect position, some modification of the CR alignment is necessary for the latter position (approximately 1 1/2 to 2 1/2 inches lower).



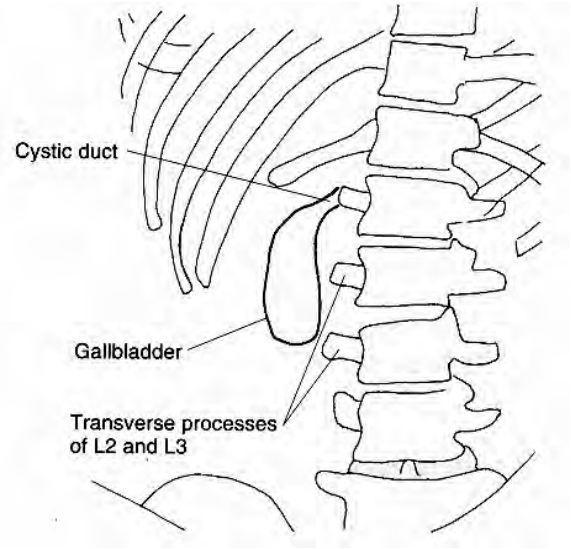


Figure 2-22. Left anterior oblique position for radiography of the gallbladder.

NOTE: Body habitus variation: Hypersthenic(broad), gallbladder is more horizontal, 2 in. higher and more lateral; Asthenic(thin), gallbladder is more vertical, 2 in. lower, near the midline of body.

(7) Special methods for radiography of the gallbladder may include the use of spot-film or tomography.

(a) Spot-filming. Following exposure and processing of the survey film, the patient is positioned under the fluoroscope, and the radiopaque gallbladder is localized. Various spot-film exposures may be obtained with the patient in either the recumbent or the erect position.

(b) Tomography. Though still used, has mostly been replaced with computerized tomography and ultrasound. After accomplishing the routine survey film, the radiologist specifies the number of layers or "cuts" to the spot-filmed and also the level at which each is to be made. By the use of tomographic technique, it is possible to avoid troublesome gas pockets and loculi or, at least, to lessen their adverse effects. Also, under certain conditions, gallstones casting doubtful densities when produced by conventional radiography can be more readily distinguished.

(c) Ultrasound. A preferred method of visualizing the gallbladder is the ultrasound. This reduces the patient’s exposure to ionizing radiation.

(8) The cholecystographic series is usually terminated with the final film begin taken 1/2 to 1 hour after ingestion of a "fatty meal" that is given to the patient immediately after satisfactory demonstration of the gallbladder.

b. **Intravenous Method.**

(1) The preparation of the patient and the radiographic procedure are essentially the same as for the oral method. The patient is given nothing by mouth the night before. The difference lies in the contrast medium used, the time at which it is introduced, and the method of introduction.

(2) A cholecystopaque, such as cholografin sodium, is injected into the vein of the arm.

(3) Radiographic examination is made in accordance with established routine--usually about 4 hours after injection. Additional films may be taken at subsequent intervals.

(4) A fatty meal is given to the patient if this has been ordered by the radiologist.

2-9. CHOLANGIOGRAPHY

Cholangiography is a procedure for the demonstration of the biliary tract after the introduction of a contrast medium. The contrast medium may be introduced by either of two methods: direct and intravenous.

a. **Direct Method.** The direct method embraces two types of procedures: operative (immediate) and postoperative (delayed).

(1) Immediate or operative cholangiography.

(a) This procedure is carried out in the operating room. The surgeon aspirates the bile in the ducts and injects a contrast medium such as Hypaque or Hippuran into the duct.

(b) A mobile x-ray unit, a portable high-speed grid cassette, and an adequate supply of loaded cassettes, are used. The cassette tray with handle is first loaded with a cassette; then it is positioned under the patient before the surgery is started.

(c) The cassette tray handle is graduated with a centimeter scale. A scout film is made to check positioning and the handle is marked, this enables the technician to reposition the cassette tray during surgery. All movement of the cassette tray is done at the head end of the table. Since the operative site is sterile-draped when the tube is moved into position, the x-ray specialist must ask the surgeon to point out the exact site for directing the CR.

(d) It is necessary to use as short an exposure time as possible, especially when other than spinal anesthesia is used. If spinal anesthesia is given, the patient should be instructed to suspend respiration during the exposure of the film. If the patient cannot respond, ask the anesthesiologist to suspend the patient's respirations during the exposure.

(e) Since the exposure must be made at a critical time during injection of the contrast medium, the specialist should ask the surgeon to give him a signal so that he can expose the film at the proper time.

(f) Before exposing the film, the specialist should direct his attention to the surgical site to make certain that none of the surgical instruments overlie or obscure the area to be x-rayed. This is extremely important. Failure to observe this precaution may necessitate re-exposure and delay the surgical procedure.

(g) Exposed films should be processed immediately for reading. Additional films are made at the request of the surgeon.

(h) The entire procedure must be carried out under aseptic conditions. Ensure that you pay attention to all sterile fields and patient drapes, taking care not to contaminate those areas.

(i) A representative cholangiogram made during surgery is shown in figure 2-23. A sketch to aid in positioning the patient is shown as figure 2-24.

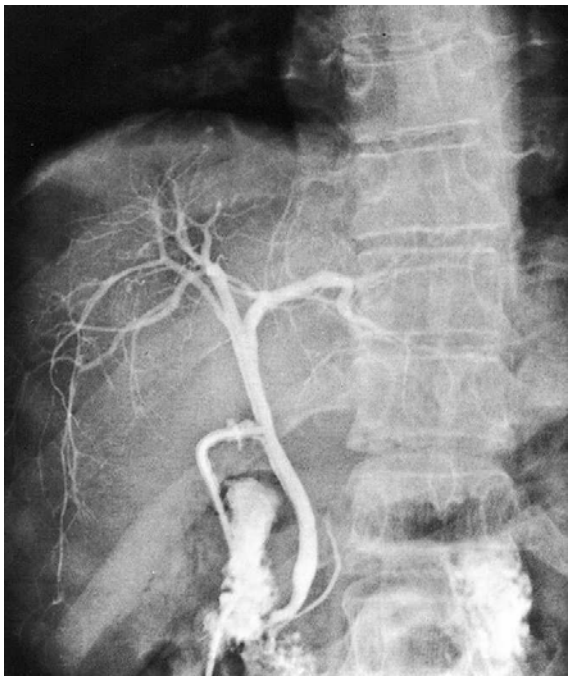


Figure 2-23. A representative cholangiogram made during surgery.

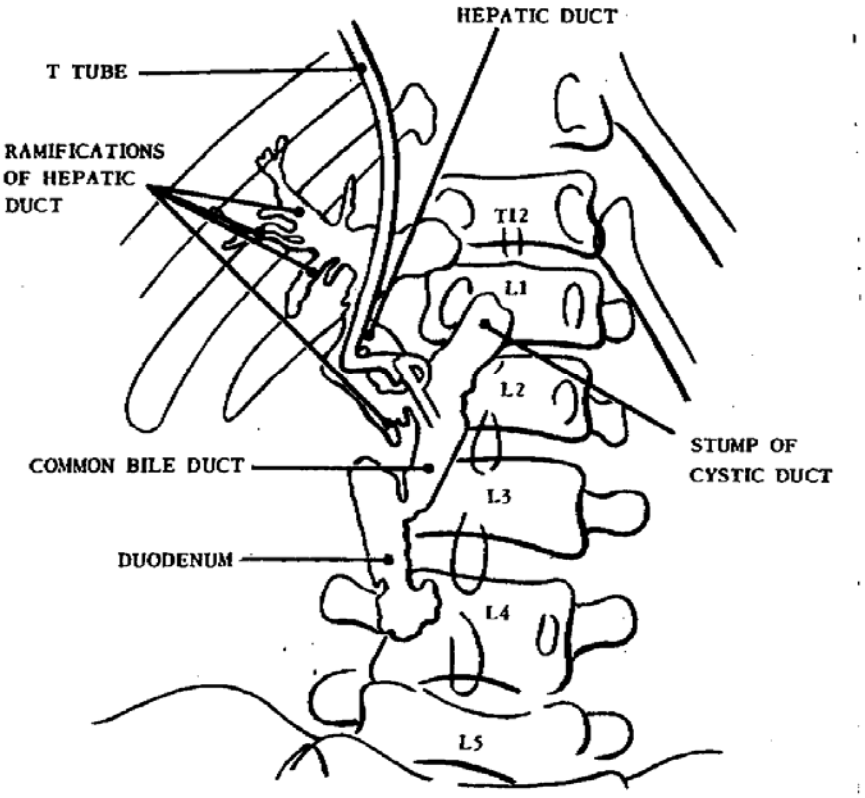


Figure 2-24. Drawing showing structures in a cholangiogram.

(2) Delayed cholangiography. This examination usually follows the removal of the gallbladder and is normally performed in the x-ray department. Following surgery, a T-tube is left in place within the biliary tract for continuous drainage. Utilizing the same type of contrast medium as for immediate cholangiography and eliminating the need of anesthesia, the material is injected through the T-tube into the biliary tract by the radiologist. The radiologist will also decide the type and the number of radiographs to be made.

b. **Intravenous Method.**

(1) Usually, the patient does not eat or drink anything after 6 p.m. on the day prior to the examination.

(2) On the morning of the examination, the patient is given a sensitivity test. If there are no contraindications, the radiologist slowly injects intravenously 40 cc of cholangiopaque (Cholografin).

(3) Ten minutes after the injection, the first film is made. Meanwhile, observe the patient for any reaction.

(4) RPO radiographs are casually made to prevent superimposition of the common bile duct over the spine. Body rotation is 15 to 20 degrees.

(5) The initial film is processed immediately and is read by the radiologist. This film also provides the specialist a means of checking for the proper positioning of the patient and the corrections of the exposure factors.

(6) Subsequent films are exposed at 10-minute intervals for the first hour and at 20-minute intervals for the second hour. In each instance, the film is processed immediately and read by the radiologist.

(7) Ordinarily, this completes the examination. However, under certain conditions, tomographic variations of positioning may be used.

Section II. THE UROGENITAL SYSTEM

2-10. INTRODUCTION

a. The urogenital system is described in subcourse MD0956.

b. Urography is the radiographic study of the functional and structural aspects of the parts of the urinary tract after they have been rendered radiopaque. This term embraces two methods of examining the kidneys utilizing a contrast medium--excretory urography and retrograde urography. Excretory urography is a functional examination and retrograde urography is a structural examination. In either case, specific patient preparation is required. In retrograde urography, the contrast medium is introduced directly into the renal pelvis via the ureter using special catheters. In excretory urography, the contrast medium is usually injected intravenously and passes quickly into the urine; however, it can be introduced intramuscularly, subcutaneously, or orally, depending upon clinical contingencies. Excretory urography is commonly referred to as intravenous pyelography and retrograde urography is commonly referred to as retrograde pyelography. The films thus obtained are called pyelograms.

c. Terms applied to other urographic examinations and the organs to which they pertain are given below.

(1) Ureterography--ureters.

(2) Cystography--urinary bladder.

(3) Urethrography--urethra.

(4) Prostatography--prostate.

(5) Epididymography--epididymis.

(6) Vesiculography--seminal vesicles.

(7) Hypertrography or uterography--uterus.

(8) Hysterosalpingography or uterosalpinography--uterus and oviducts (fallopian tubes).

(9) Nephrography--kidney tubules.

2-11. INTRAVENOUS PYELOGRAPHY

a. **Patient Preparation and Scheduling.** Preparation and scheduling of the patient depends upon local policies and may include the following.

(1) Requests for this examination should be properly filled and by the referring medical authority and submitted to the radiology service.

(2) In some hospitals, intravenous pyelography is the responsibility of the urology section of the surgical service.

(3) Radiopaque pills or tablets **should not** be given to the patient prior to the examination.

(4) The gastrointestinal tract should be empty; the patient should be given a cathartic at least 12 hours prior to the examination.

(5) The patient should not have any fluids or foods by mouth after 10 p.m. on the evening before the examination. If it is necessary to dehydrate the patient, a longer period of abstention from fluids may be prescribed.

(6) The patient should void just prior to the examination.

b. **Equipment.**

(1) Radiographic-urological table. A special radiographic-urological table, readily tiltable, is the most practical and convenient apparatus for urographic examinations. Ordinarily, this unit is equipped with a Potter-Bucky diaphragm, leg and shoulder rests, and immobilization band. It should be used in combination with an x-ray tube and generator of sufficient capacity to minimize the adverse effects of motion (blurring) by permitting the utilization of short exposure times. For the structural arrangement of this unit, see figure 2-25. It is often located in the urological service or in an operating room suite where accessory items of equipment, contrast media, and medical items are conveniently stored. The urological suite often has its own darkroom. This setup is especially desirable when the urological service has a large patient population that suffers from urological diseases.

(2) Conventional x-ray table unit. This unit should be equipped with a Potter-Bucky diaphragm, foot and shoulder rests, and immobilization band, and should be tiltable. The tube and generator should be of ample capacity to allow for short exposure times.

Figure 2-25. Table, radiographic-urological.

c. **Administration of Contrast Medium.**

(1) The contrast medium (contained in an ampule) should be warmed to body temperature in a basin of water.

(2) An "IVP (intravenous pyelography) layout" should be made available in accordance with an established routine. This layout may consist of such items as:

(a) Syringes, sterilized--a 20 cc, 30 cc, or 50 cc syringe for the injection of the contrast solution and a 2 cc syringe for the administration of the sensitivity test or adrenalin.

(b) Needles of specific size and number, sterilized.

(c) Ampule file.

(d) Ampules of adrenalin.

(e) Tourniquet.

(f) Alcohol.

(g) Gauze bandages, sterilized.

(h) Hand towels, sterile.

(i) Small water basin, sterilized.

(3) Either the radiographic-urological table or the conventional x-ray table may be used. The patient is placed on the table in the supine position with the midline of the body aligned to the center of the table (figures 2-26 and 2-27).

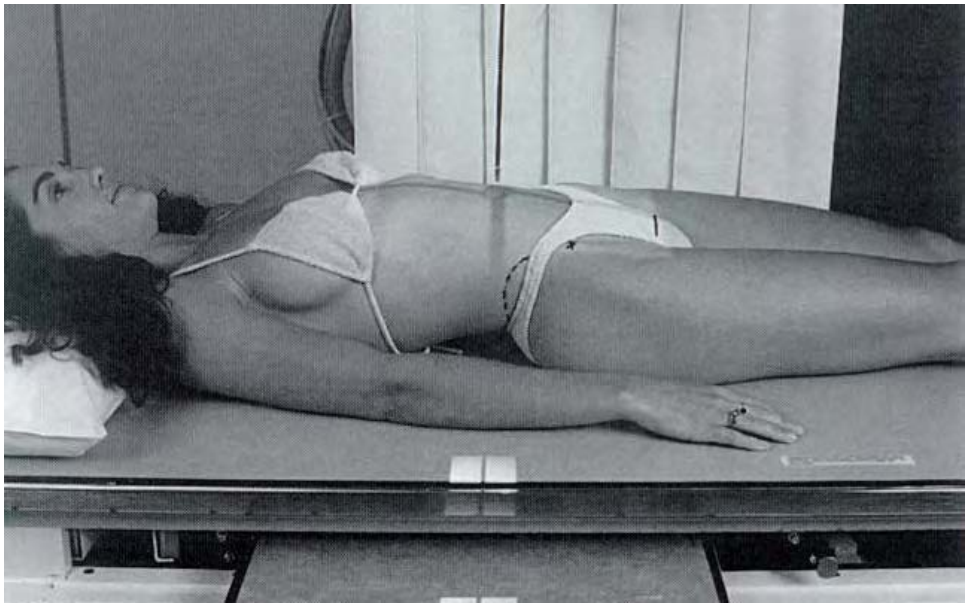


Figure 2-26. Patient in position for urography.

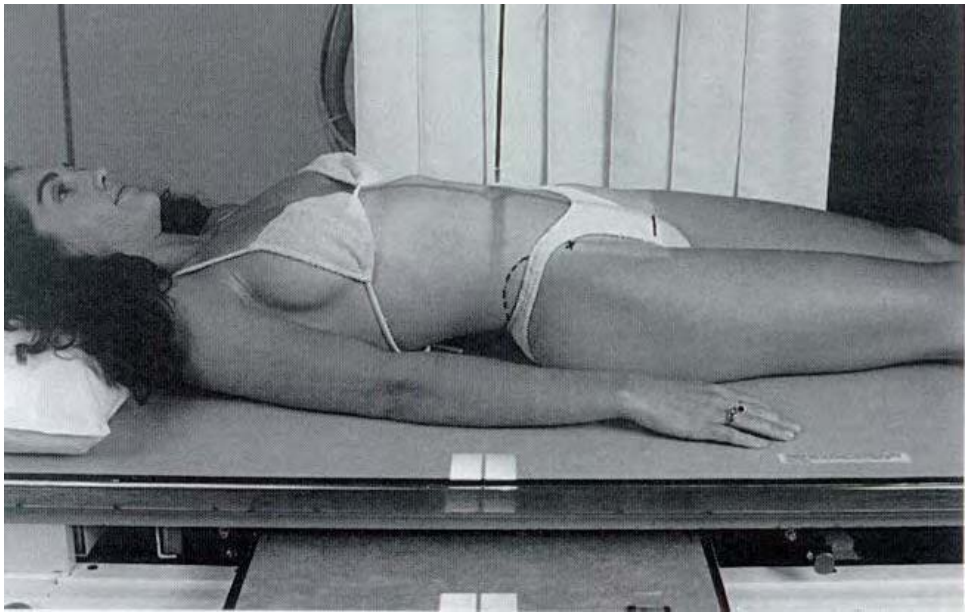


Figure 2-27. Abdomen, AP (K.U.B.).

(4) Ordinarily, the patient is given a minute quantity of the contrast medium (orally, ophthalmically, subcutaneously, or intravenously) to determine sensitivity.

(5) A K.U.B. (kidneys, ureters, bladder) film should be made before the injection of the contrast medium. This film should be processed immediately and given to the radiologist or other responsible medical authority for examination. It will show whether or not the gastrointestinal tract has been properly cleared and demonstrate the presence of any calculi or any outstanding pathology. It also serves as a means of checking for correctness of technique factors and accuracy of positioning.

(6) After preliminary testing, a sterile aqueous contrast solution containing from 35 to 50 percent iodine compound (for example, Conray, Renografin, or Hypaque) is injected slowly into one of the antecubital veins at the elbow. THE INJECTION IS ALWAYS GIVEN BY THE RADIOLOGIST OR ANOTHER PHYSICIAN.

NOTE: Non-ionic contrasts are the media of choice, resulting in fewer severe reactions.

d. **Radiography.**

(1) In general, the positioning of the patient (figure 2-27) and the technique factors are the same as for the routine K.U.B. procedure.

(2) Films are exposed at specified intervals. Exposure time should as short as practicable to minimize motion and increase detail. Unless otherwise specified, exposure is made upon suspension of respiration at the end of exhalation. Exposures are made according to clinical routine. The following sequence is an example:

(a) 1st film: 05 minutes after injection.

(b) 2nd film: 10 minutes after injection.

(c) 3rd film: 10 minutes after injection.

(d) 4th film: 20 minutes after injection.

NOTE: At least one film (normally, the last) is made with the patient in the upright position. For upright projections, the normal exposure should be increased.

(3) In addition to the above film, it is sometimes necessary to take one or more of the following:

(a) Posterior obliques right and/or left.

(b) Laterals right and/or left.

(c) Post-micturition film of the urinary bladder.

(d) Tomograms are rarely done, but some departments still have the equipment and perform studies.

(e) When computerized tomography is available, CT studies of the kidneys are done while the patient still has contrast in their system.

(4) In addition to the regular identification data, lead number markers are used to indicate the time-interval at which each film was exposed. The time-interval marker should be so placed that it is easily distinguished on the processed film. Also, be sure to identify any upright film, if any are taken, with an arrow or other appropriate marker.

(5) Unless otherwise specified, as soon as each pyelogram is exposed, it is immediately processed and presented to the radiologist for reading.

(6) To induce urine stasis for the purpose of obtaining the best filling and thereby greater concentration of the contrast medium in the renal pelvis and calyces, one of several methods may be used. The two methods most commonly used are presented below.

NOTE: Urine stasis is induced only at the request of the responsible medical authority.

(a) Gravitational method. The patient is placed in the modified Trendelenburg (20º to 40º) position, which induces urine stasis with the aid of gravity.

(b) Compression method. A radiopaque compression device, such as a suitably shaped block of balsa wood or an inflatable bag, is placed on the lower part of the patient's abdomen and the proper amount of pressure is applied by an immobilization band. See figure 2-28. Compression is usually applied before the start of the injection and released prior to the exposure of the last film. Ureterograms may be obtained while the ureters are filled with the contrast agent by exposing a film immediately after compression is released.

Figure 2-28. Patient has compression method applied.

(7) If subsequent pyelograms are to be taken, great care should be exercised to match all films with respect to position, SID, radiographic contrast, and density. This is necessary for satisfactory comparison with the results of prior urographic examinations. A representative intravenous pyelogram is shown in figure 2-29. A labeled tracing of the pyelogram is shown in figure 2-30.

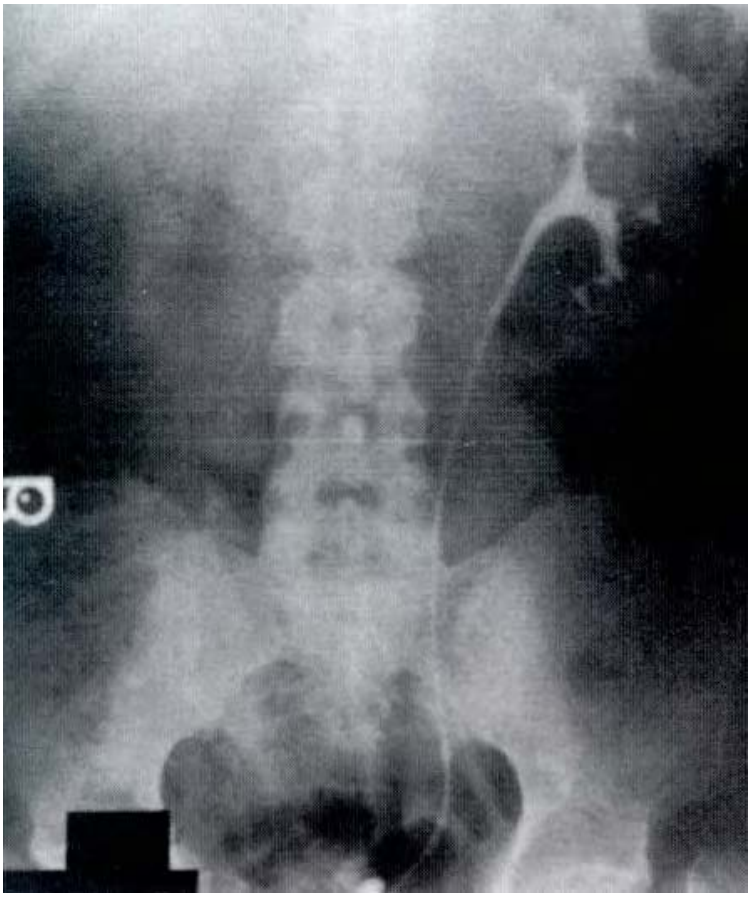


Figure 2-29. Intravenous pyelogram. Contrast medium in kidneys and ureters.

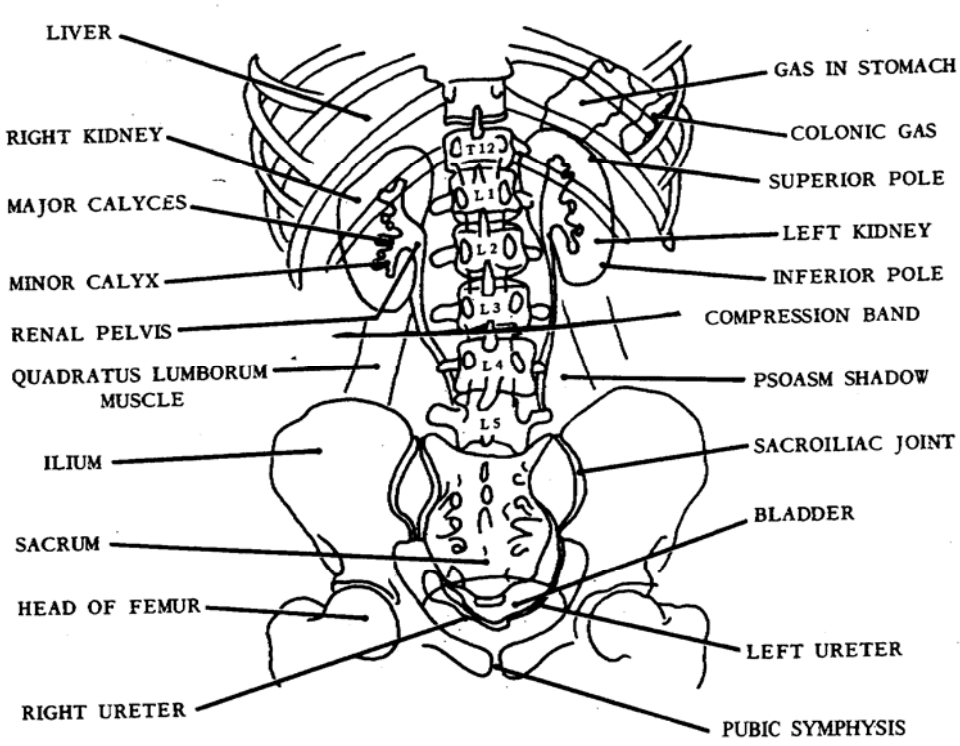


Figure 2-30. Sketch of kidney and ureter area.

e. **Precautions.**

(1) There is always the possibility of the patient having adverse reactions following injection of the contrast medium. For this reason, the following precautions must be observed:

(a) AT NO TIME DURING THE EXAMINATION WILL THE PATIENT BE LEFT UNATTENDED.

(b) Should the patient show such signs as hives, sweating, pallor, dyspnea, severe vomiting, restlessness, or rapid pulse, competent medical aid will be summoned immediately.

(c) The specialist should take care to not alarm or suggest symptoms to the patient.

(d) Treatment material must be available and ready for instant use in case an emergency should arise. An anaphylactic shock and emergency resuscitation layout should be kept in complete readiness.

2-12. RETROGRADE PYELOGRAPHY

a. **Patient Preparation and Scheduling.** Patient preparation and scheduling for pyelography is similar to that for intravenous pyelography, except for the following.

(1) Fluid intake (water) is not restricted; instead, unless otherwise ordered, fluid intake is as much as the patient will tolerate.

(2) Sedation is administered as ordered.

b. **Equipment.**

(1) The radiograph-urological table unit (see figure 2-25).

(2) Cystoscope of the type especially suited for this examination.

(3) A special layout consisting of sterile and nonsterile accessory supplies, drugs, and apparatus. The content and arrangement of this layout will vary with the case and the preferences of the urologist. A representative layout may include such items as the following:

(a) Catheters: ureteral, x-ray, 4 to 14 Fr. (French); urethral, 14 to 24 Fr.

(b) Syringes: bulb type, with assorted nozzles. Luer 2, 5, and 10 cc.

(c) Specimen bottles, culture tubes, and medicine glasses.

(d) Towels, drapes, sheets, leggings, gauze, cotton, and gloves.

(e) Tourniquet, large and small water basins, and small trays.

(f) Drugs, antiseptic solutions, and contrast solutions.

c. **Procedure.**

(1) The patient is placed on the radiographic-urological table.

(2) The patient's lower extremities are sheathed in leggings especially designed for this purpose.

(3) The urologist introduces the cystoscope via the urethra and makes a preliminary examination of the urinary bladder. He then passes the urethral catheters through the cystoscope into the ureters as far as the renal pelves.

(4) A film is usually made to check the position of the catheter(s) and to check patient position and technical factors.

(5) This film is immediately processed and presented to the radiologist or the urologist for reading.

(6) At this stage of the procedure, the urologist will, in most instances, retract the cystoscope, leaving the catheters in place.

(7) A contrast solution is introduced into the renal pelves and calyces through the respective catheters by means of syringes. This procedure is accomplished by the urologist.

(8) At this point, the following routine is usually carried out:

(a) At a signal from the urologist, the x-ray specialist exposes the pyelogram (figure 2-31). For this exposure, the patient is instructed to suspend respiration at the end of exhalation.

Figure 2-31. Retrograde pyelogram showing the urethral catheter in place and the distribution of the contrast medium in the kidney and ureter.

(b) The patient is allowed to breathe normally while the film in the Potter-Bucky tray is quickly changed.

(c) The urologist withdraws the ureteral catheters and simultaneously maintains pressure on the syringes to express the amount of contrast solution required for maximum filling of the ureters.

(d) At a signal from the urologist, the ureterographic exposure is made. The timing of the exposure is regulated so that the film will record the incidence of maximum filling of the ureters. Exposure time should be as short as practical. Such films are termed ureterograms.

(9) There are several variations of the above routine. For example, in some instances, the kidney on one side is filled and the pyelographic film is exposed. Then the same procedure is repeated for the kidney on the opposite side. The head of the table is often elevated 35º to 45º for the ureterogram to demonstrate any kinking of the ureters and to determine any downward displacement of the kidneys. On occasion, the "split-exposure" technique may be used to differentiate between a ureteral calculus and a calculus-like density superimposed with the density pattern cast by one or both of the ureters. For this technique, the first exposure is made with the x-ray tube positioned as for normal centering and the second exposure is made with the tube displaced laterally 1 1/2 to 3 inches. One half of the normal exposure time is used for the first exposure, and two-thirds of the normal exposure time is used for the second exposure. Only the tube is moved during this procedure, the position of the patient and the film remains constant.

(10) In actual practice, the number and kind of films exposed depends upon the patient's symptoms. The x-ray specialist should be prepared to take such views as posterior-obliques, or laterals.

2-13. CYSTOGRAPHY AND PNEUMOCYSTOGRAPHY

a. **General.** Cystography is the radiographic study of the urinary bladder after the introduction of a radiopaque contrast medium. The films thus obtained are cystograms. When a radiolucent contrast medium (such as air) is used, the examination is termed pneumocystography and the film is a pneumocystogram.

b. **Patient Preparation and Scheduling.**

(1) Unless specific orders are given, patient preparation and scheduling are the same as for pyelography.

(2) The patient is instructed to void before being placed on the x-ray table.

c. **Equipment.**

(1) The conventional x-ray unit equipped with a Potter-Bucky diaphragm and a tilting mechanism is preferred.

(2) When cystoscopy is required, the radiographic-urological table unit may provide certain advantages.

(3) A cystoscopic layout that suits the needs of the given case should be readily available. Ordinarily, this layout is made up and supplied.

d. **Procedure.**

(1) The patient is placed on the table in the supine position with the median plane of the body centered to the midline of the table. A 10 x 12-inch film is placed lengthwise in the Potter-Bucky film tray and it is centered 1 inch above the symphysis pubis on the median plan of the body. The CR (central ray) is projected perpendicularly and directed to the center of the film. A preliminary film of the bladder region is made upon request of the examiner.

(2) To clear away any gas in the rectum, a rectal tube may be inserted. The tube must be removed before the exposures are made.

(3) The urologist introduces a contrast medium, such as Cystokon, into the bladder through a urethral catheter in an amount sufficient to distend the bladder (200 to 300 cc). To retain the contrast solution in the bladder during radiography, the catheter should be clamped.

(4) Cystograms are exposed with the patient's respiration suspended at the end of exhalation. The first exposure is an AP projection of the bladder region. Usually, right and left posterior-obliques (45º to 60º body rotation) (figure 2-32) are made following the AP projection. Additional exposures may include lateral or stereoscopic projections in the prone or supine positions. A representative cystogram is shown in figure 2-33.

(5) In some cases, the AP projection is taken with CR angled 15º to 25º caudad from the vertical relationship (figure 2-34). Similar results may be obtained with a perpendicular CR and the head of the table elevated 15º to 25º (figure 2-35).

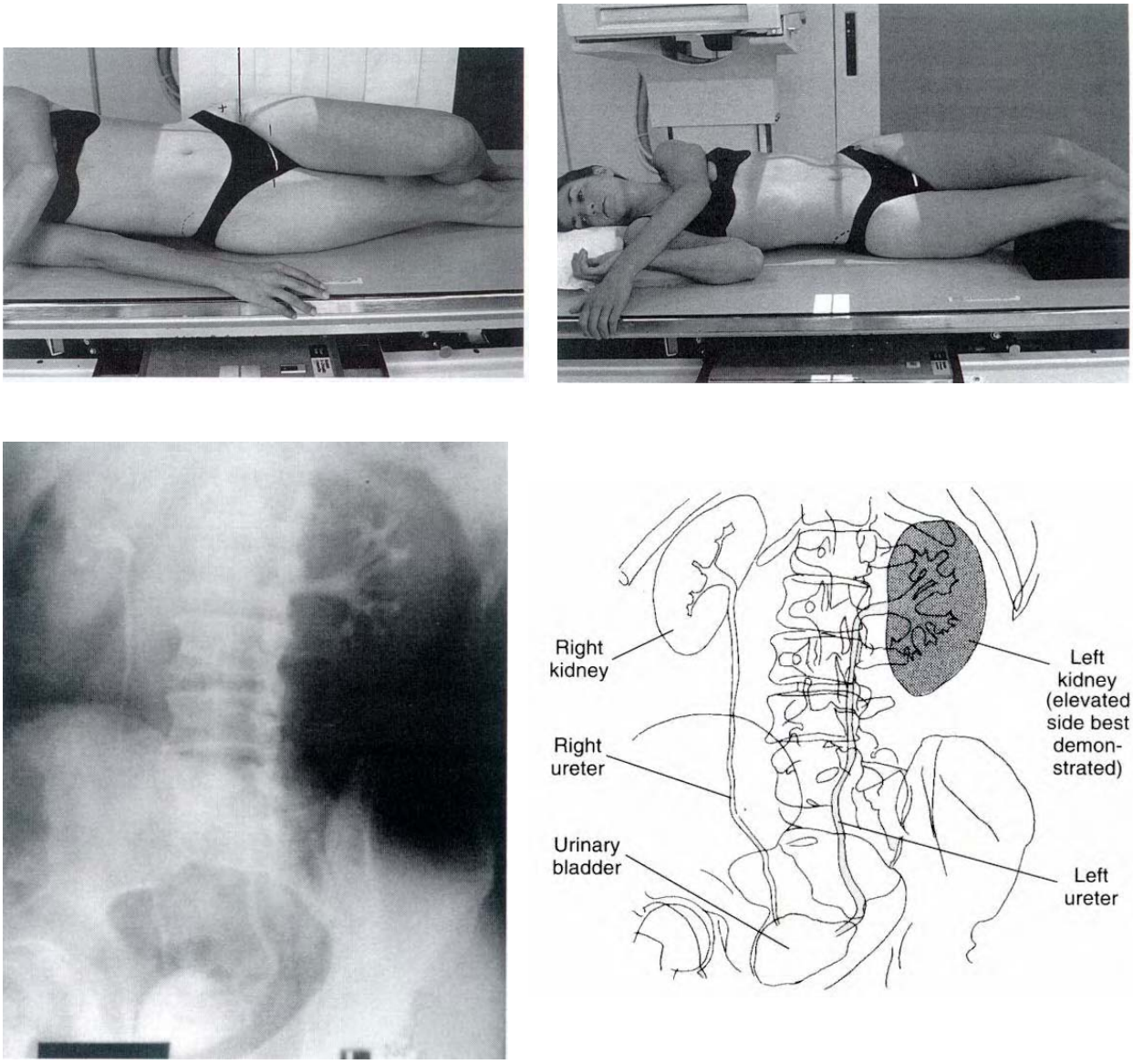


Figure 2-32. Right posterior-oblique position for cystography. Note relationships of part, film, and central ray.

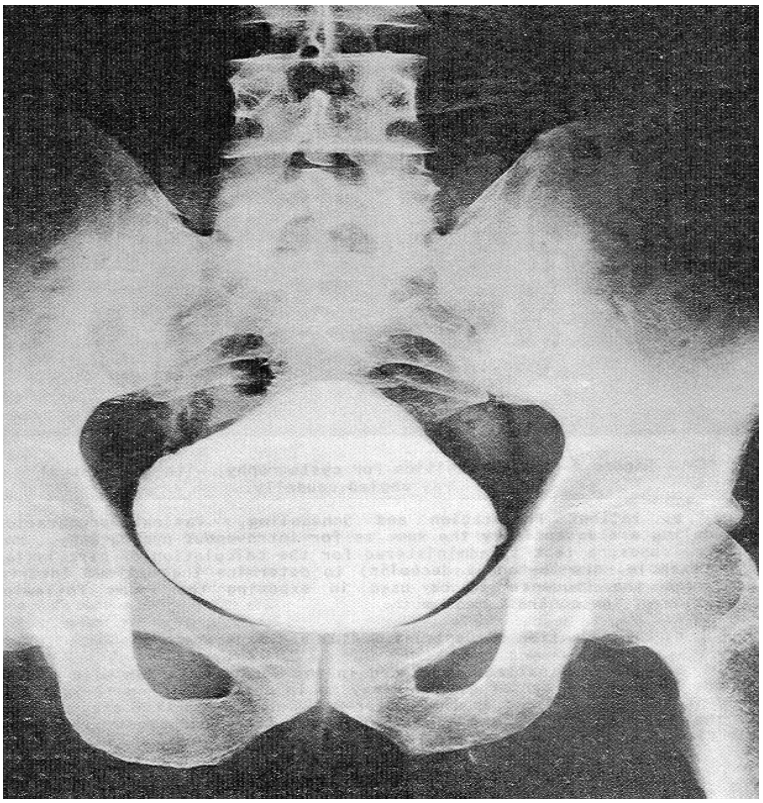


Figure 2-33. A representative cystogram.

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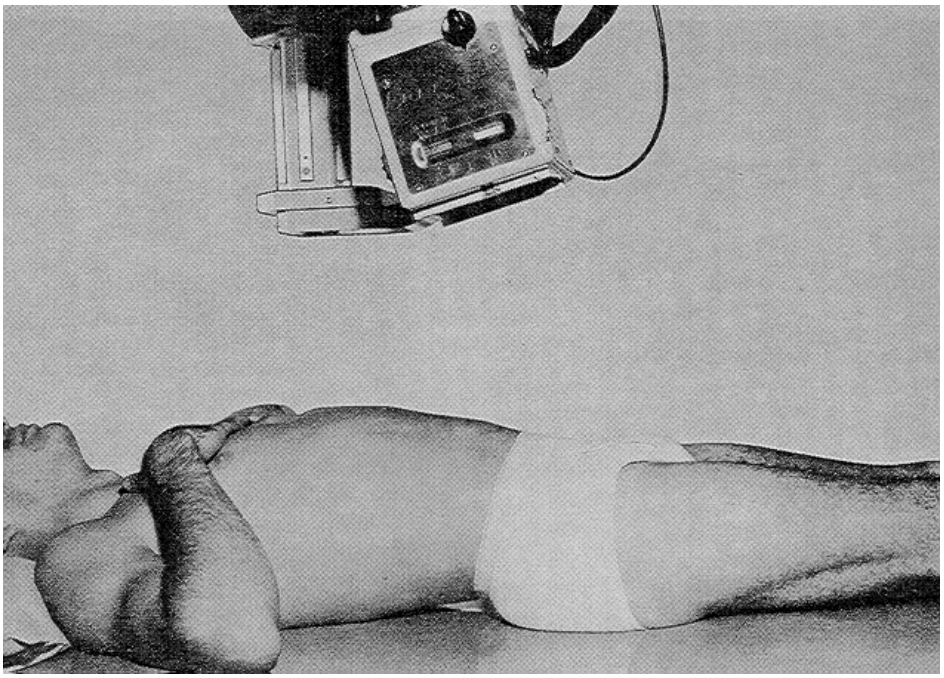


Figure 2-34. AP position for cystography, with the central ray angled caudally.

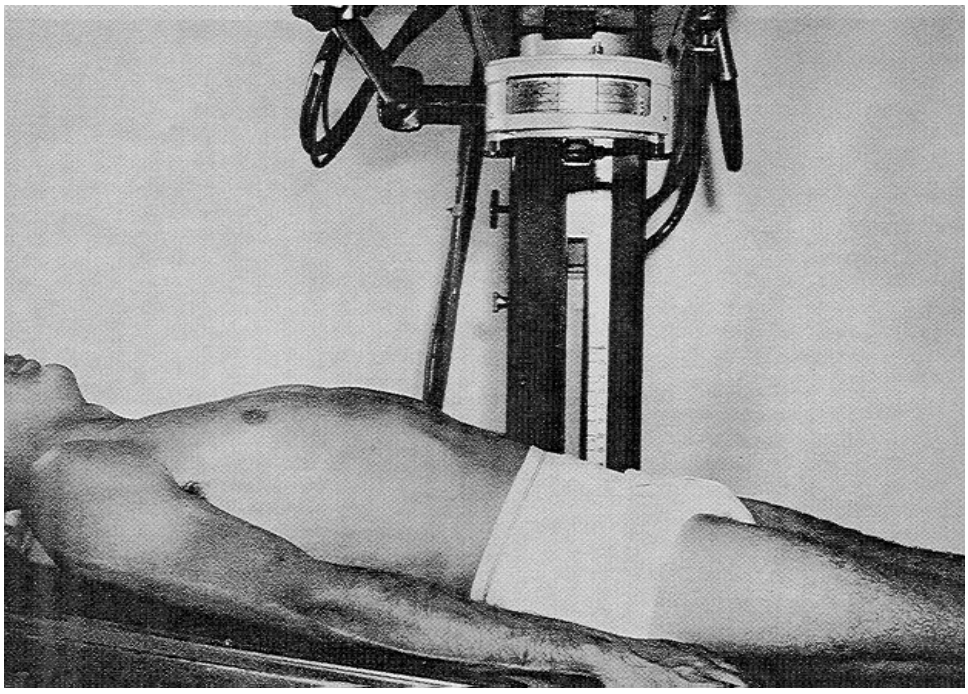


Figure 2-35. AP position for cystography, with the head of the x-ray table elevated and the central ray perpendicular is angled to the caudad to demonstrate the bladder region.

(6) For pneumocystography, the positioning procedure is generally the same as for cystography. However, AP and PA projections are considered the basic projections for this examination. The exposure time should be decreased by 40 to 50 percent from that used for cystography because of the radiolucency of the induced spaced occupied by the injected air. A representative pneumocystogram is shown in figure 2-36. For double-contrast studies, a special colloidal solution is first introduced into the bladder and then withdrawn, leaving a residual coating of the substance on the mucosa. Air is then injected and the pneumocystogram is taken.

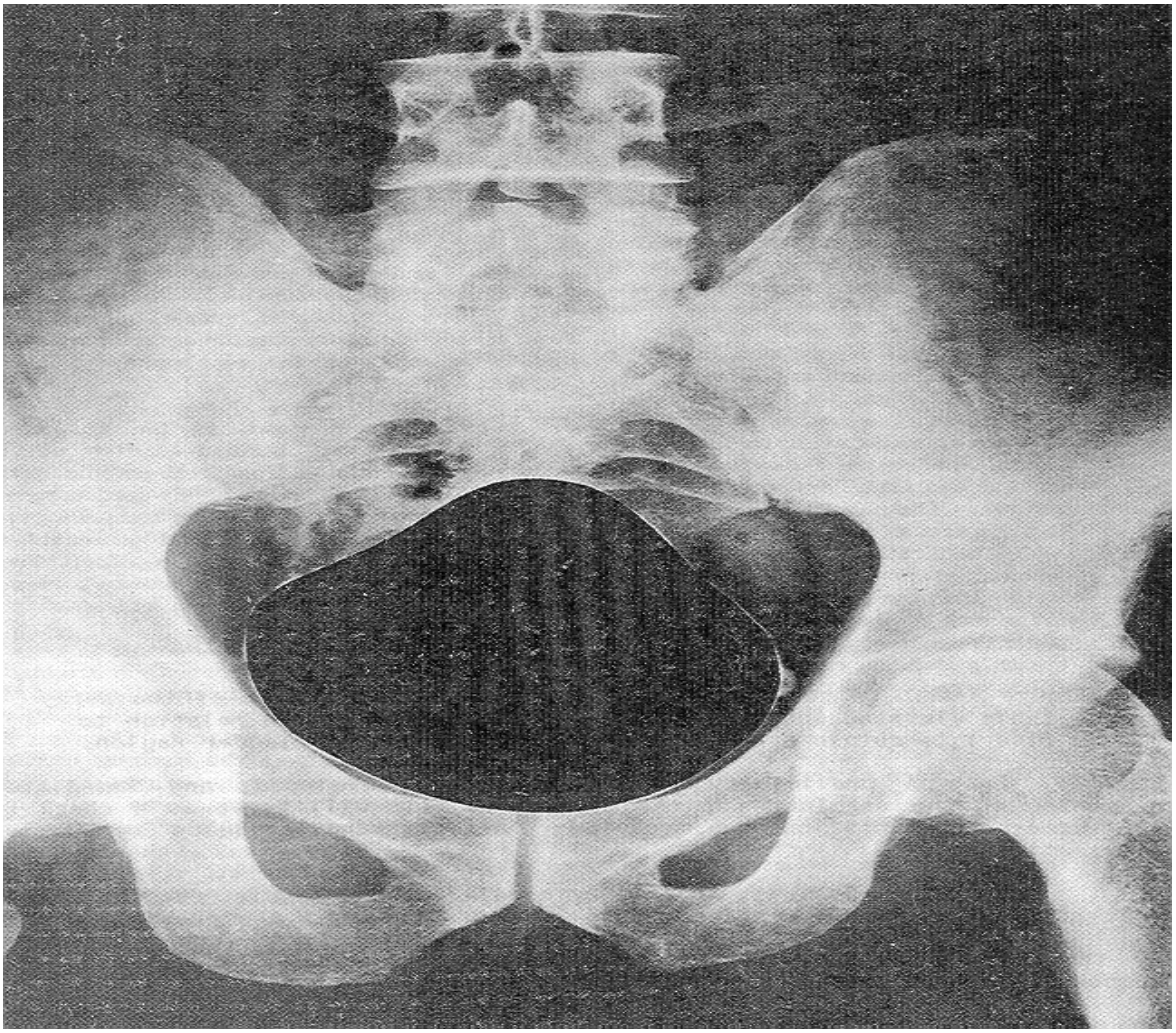


Figure 2-36. A representative pneumocystogram.

2-14. NEPHROGRAPHY

a. **General.** Nephrography is a special procedure for the radiographic demonstration of the parenchymal structures of the kidneys during their radiopacification by means of a contrast medium.

b. **Patient Preparation and Scheduling.** Patient preparation and scheduling are essentially the same as for intravenous pyelography. However, in some cases, a test is administered for the calculation time (for example, arm-to-tongue decholin) to determine the optimum intervals of time and the sequence to be used in exposing the films following the injection of the contrast medium.

c. **Introduction of Contrast Medium and Radiography.**

(1) The patient is placed in the supine position with the midline of the body to the center of the x-ray table unit. A 10x12-inch or a 14x17-inch film is placed in the Potter-Bucky diaphragm film tray and centered at the level of the 2d lumbar vertebra. The CR is directed to the center of the film.

(2) The pertinent aspects of the procedure should be explained to the patient, and he should be warned about the sensations he is likely to experience during the procedure (such as hot flashes, gagging, and nausea). The necessity for controlling respiratory or bodily movements during the exposure of the films should be stressed.

(3) A preliminary film is exposed, developed, and immediately presented to the examiner for reading. This film will serve as a check for correctness of positioning, technique factors, and adequacy of patient preparation.

(4) A 12-gauge injection needle (for example, Robb-Steinberg type) is inserted into an antecubital vein of the arm. A wide-bore syringe that has been previously filled with the contrasting medium (consisting of one of the sterile aqueous solutions and containing 70 to 75 percent iodine compound such as Hypaque or Renografin) is attached to the needle.

(5) With all participants alerted, technique factors selected, and x-ray apparatus in readiness, the examiner gives the "ready" signal and starts injecting the contrast medium (40 to 50 cc). As the last of the contrast solution leaves the syringe, the examiner calls out, "Now," at which time the x-ray specialist (or an assistant) starts a stopwatch or audibly counts the passage of seconds on any available timepiece which has a second hand.

(6) The first film is exposed at a predetermined interval following the injection of the contrast solution. This interval usually ranges from 8 to 20 seconds, depending upon the circulating time. Subsequent films are exposed at predetermined intervals. If a conventional x-ray unit is being used, the subsequent exposures should be made as rapidly as possible, especially during the critical filling phase or when there is maximal concentration of the contrast material in the cortical and medullary regions of the kidneys. The patient is instructed to hold in his breath and exposure is made on full inspiration. If a rapid-sequence serializing apparatus is used, two or more (only when indicated by the examiner) exposures may be made while the patient continues to hold his breath. Usually, exposure of films is discontinued approximately 35 seconds following the completion of the injection.

(7) The identification marker should be placed on each of the cassettes prior to beginning the examination.

(8) All films should be developed as quickly as possible and presented to the examiner for reading before the patient is moved off the x-ray table.

(9) Nephrograms may sometimes result as a side-effect. They are apt to occur during such special procedures as angiocardiography or aortography, wherein relatively large amounts of contrast solution containing a high percentage of iodine are introduced at a relatively rapid rate.

(10) A representative nephrogram is shown in figure 2-37.

Figure 2-37. A representative nephrogram.

2-15. NEPHROTOMOGRAPHY

a. **General.** Nephrotomography is a special procedure for the sectional representation of the parenchymal structures of the kidneys by the use of tomography during radiopacification following the intravenous administration of a contrast medium. This technique helps to obtain a clearer image of the renal parenchyma by blurring out the image details of underlying and overlying structures.

b. **Patient Preparation and Scheduling.** Unless otherwise indicated, patient preparation and scheduling for nephrotomography is essentially the same as for nephrography.

c. **Procedure.**

(1) Two AP radiographs of the abdominal region are obtained, one by use of conventional radiographic technique, the other by tomography. The two films are processed immediately and presented to the examiner for reading. They serve as control films and as a means for checking the correctness of the technique factors.

(2) Any necessary adjustments in regard to positioning of the patient are made, the tomographic fulcrum is set at the correct elevation, and the contrast medium is introduced. Usually, the introduction of the contrast medium is done as for nephrography. The numbers of exposures to be made during radiopacification of the renal parenchyma, as well as the exact exposure time-intervals to be used, are predetermined by the examiner according to circulation time.

(3) All films should be developed immediately after exposure and presented to the examiner for reading prior to releasing the patient.

2-16. URETHROGRAPHY

a. **General.** Urethrograms are accomplished by radiography of the urethra after filling with a suitable contrast medium.

b. **Patient Preparation.** No special preparation of the patient is required, but the patient is requested to void just prior to examination.

c. **Equipment.**

(1) Either a conventional x-ray unit equipped with a Potter-Bucky diaphragm or a radiographic-urological table unit.

(2) Sandbags or cellulose positioning blocks for supporting and immobilizing the patient in the required position.

(3) Routine layout for administration of contrast media.

d. **Procedure.**

(1) The urologist irrigates the urinary bladder.

(2) A preliminary film (or films) of the urogenital tract is exposed as ordered.

(3) The patient is placed on the x-ray table in the posterior-oblique position with the body rotated 35º to 40º, either to the right. For male patients, the penis is extended along the medial aspect of the thigh nearest the film. The region of the symphysis pubis is centered to the midline of the table. The knee nearest the table surface is moderately flexed. The leg farthest from the table surface is extended and moved slightly backwards. Sandbags are placed to secure and immobilize the position. See figure 2-38.

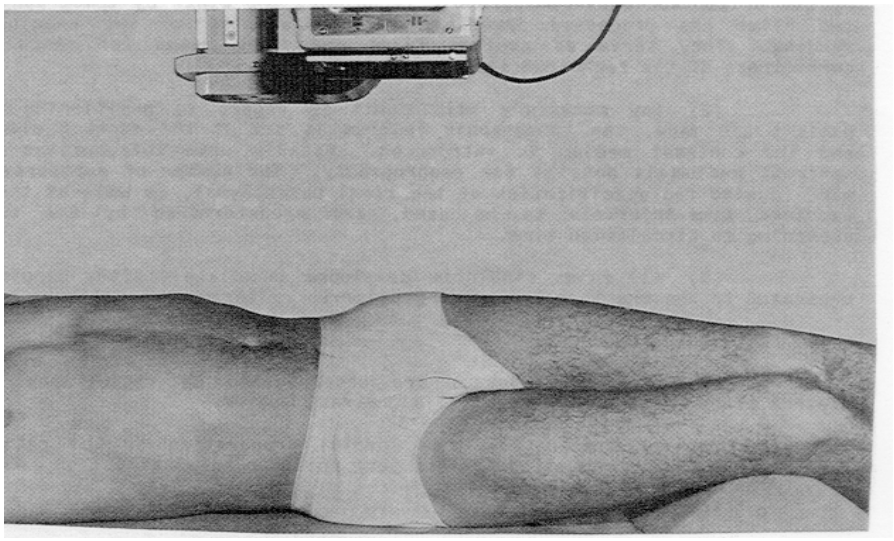


Figure 2-38. The right posterior oblique position for urethrography.

(4) A 10 x 12-inch film is placed lengthwise in the Bucky tray with the mid-length aligned at the level of the interior border of the symphysis pubis.

(5) Proper collimation is used.

(6) The CR is projected perpendicularly and directed to the center of the film.

(7) The urologist introduces a contrast medium (viscous solution) into the urethra.

(8) Exposure is made at a signal from the urologist. Routine pelvic technique factors are appropriate. Respiration is suspended during exposure.

(9) The foregoing procedure may be varied by taking AP or PA projections of the filled urethra using screen or cardboard (non-Bucky) technique. For these radiographs, the patient's legs are parted, the penis is positioned to the central portion of the film, and the CR is angled about 12 degrees caudad from the vertical relationship. Routine digit technique factors are appropriate.

(10) A representative urethrogram is shown in figure 2-39

Figure 2-39. A representative urethrogram.

2-17. HYSTEROSALPINGOGRAPHY (UTEROSALPINGOGRAPHY)

a. **General.** This procedure deals with radiographic and/or fluoroscopic examination of specified structures of the female reproductive system utilizing a contrast medium. The radiography is hysterosalpingogram. The specified technique will depend upon the nature of existing pathology, the condition of the patient, the special types of apparatus, and the preferences of the examiner. The general principles of the procedure are presented herein primarily for guidance.

b. **Patient Preparation and Scheduling.**

(1) A properly filled out request form is submitted to the x-ray department by the referring medical authority.

(2) Examination is usually scheduled 1 to 8 days after menstruation or at a time determined by the gynecologist or radiologist.

(3) The patient's lower bowels should be cleared of gas and fecal material, as ordered by the responsible medical authority.

(4) The patient is requested to void just prior to the examination.

c. **Procedure.**

(1) The patient is placed in the supine position with the median plane of the body aligned to the midline of the combination radiographic-fluoroscopic table. If fluoroscopy is not to be done, the standard radiographic-urological table unit may be preferred.

(2) A 10 x 12-inch film is placed lengthwise in the Potter-Bucky film tray with the mid-length of the film aligned to the level of the ASIS. The CR is projected perpendicularly and directed to the center of the film. Collimation should be used to confirm the field of irradiation to the most practical limits.

(3) A preliminary film is exposed as ordered. Routine pelvic factors will serve for basic exposure technique.

(4) The gynecologist or the radiologist introduces a vaginal speculum.

(5) A cannula is inserted into the cervical canal of the uterus.

(6) The gynecologist injects from 3 to 10 cc radiopaque contrast material (usually Salpix) containing from 35 to 40 percent iodine compound. In some instances, the course of the contrast medium is observed fluoroscopically. Spot-filming is done by the radiologist, when necessary.

(7) Hysterosalpingograms are exposed by the specialist in a given signal from the gynecologist. Respiration is suspended for the exposure.

(8) Additional films are taken as ordered. For example, these may include one or more of the following:

(a) AP projection with or without caudal angulation of the CR.

(b) PA projections with or without cephalad angulation of the CR.

(c) Obliques, anterior or posterior (right and/or left).

(d) Decubitus--AP, PA, or lateral projections.

(e) Video taping the fluoroscopy during injection.

(f) Pelvic inlet views.

(g) Digital recordings.

(9) Sometimes a pelvic pneumoperitoneum exposure may be performed to demonstrate the external contours of the uterus and adjacent structures. For this procedure, approximately 500 cc of carbon dioxide or oxygen is introduced into the peritoneal cavity. The gynecologist introduces the radiolucent contrast medium or radiologist while the patient is in the Trendelenburg position. For radiography, the patient is turned in the prone position, and the table is tilted 45º to 50º to bring the hips above the level of the head (figure 2-40). The CR is projected vertically and directed through the region of the rectum to the center of the film. The exposure mAs should be reduced by approximately one-half of the normal. Other radiographs are taken as ordered.

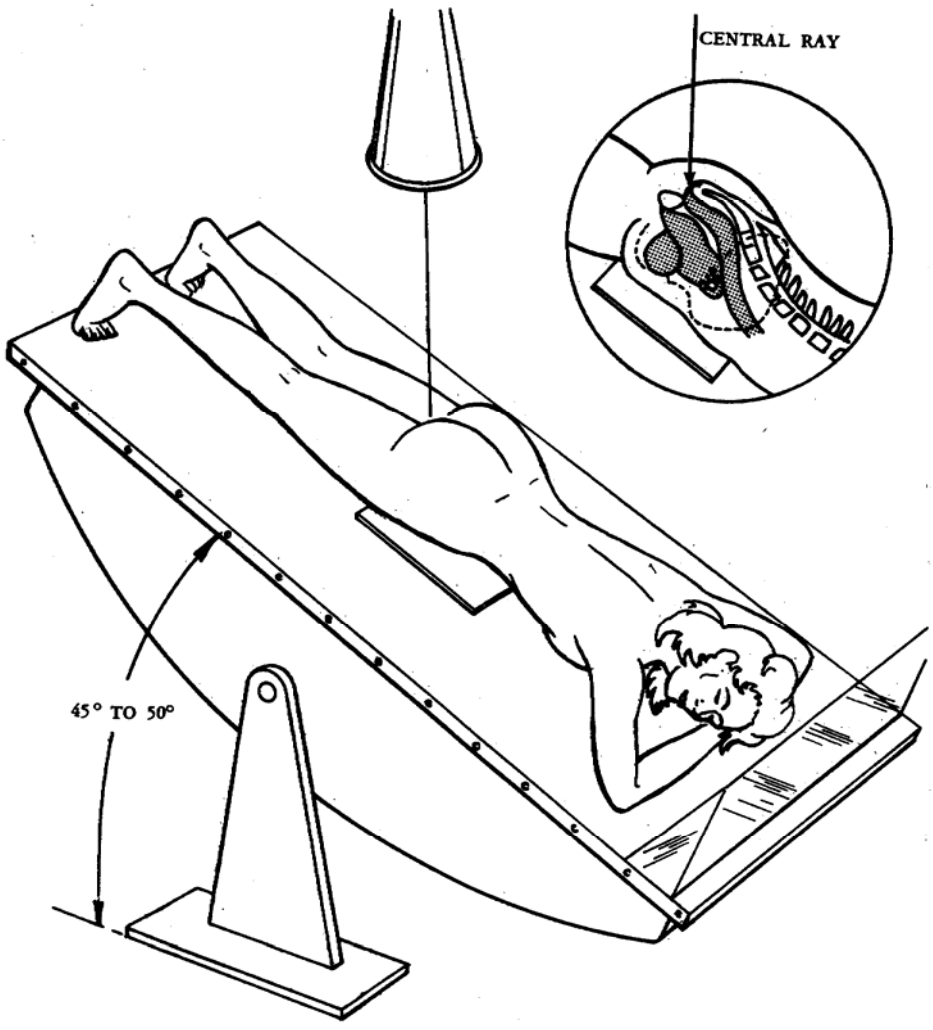


Figure 2-40. Patient positioned for pelvic pneumoperitoneum.

Section III. THE DECUBITUS POSITIONS

2-18. ESSENTIALS OF THE POSITIONS

In any radiographic decubitus position, two conditions coexist:

a. The patient must be lying down.

b. The central ray (CR) must be horizontal.

2-19. DESCRIPTION

a. There are four decubitus positions--dorsal, ventral, right lateral, and left lateral (figure 2-41). These names signify the surface of the body upon which the patient is resting in a recumbent position. In the dorsal decubitus position, the patient is supine. In the ventral decubitus position, the patient is supine. In the right lateral decubitus position, the patient is lying on his right side. In the left lateral decubitus position, the patient is lying on this left side.

b. Using a horizontal CR, it is possible to secure two different projections for each decubitus position. The lateral projections (right and left) can be accomplished with the patient in either the left lateral decubitus or right lateral decubitus position.

c. If a “PA projection of a left lateral decubitus position” is requested, the projection should be made as the patient lies on his left side. The vertical film holder should be supported at the anterior aspect of the patient's body; the horizontal CR should enter the posterior surface and exit at the anterior surface. For a left lateral projection of a dorsal decubitus position, the patient should be in a supine position. The vertical film holder should be supported at the left side of the patient; the horizontal CR should enter the right side and exit from the left. Lateral projections of dorsal or ventral decubitus positions of the thorax or abdomen may also be referred to as "transthoracic" (transabdominal)."

2-20. CLINICAL USE

Decubitus positions are used for two main reasons:

a. To effect a shift of fluid, air, contrast media, or anatomical part so that additional diagnostic information can be obtained in a radiograph.

b. To make desired radiographs that would ordinarily be accomplished by rotating a part and using a perpendicular CR, but cannot be performed in this instance because of the condition of the patient.

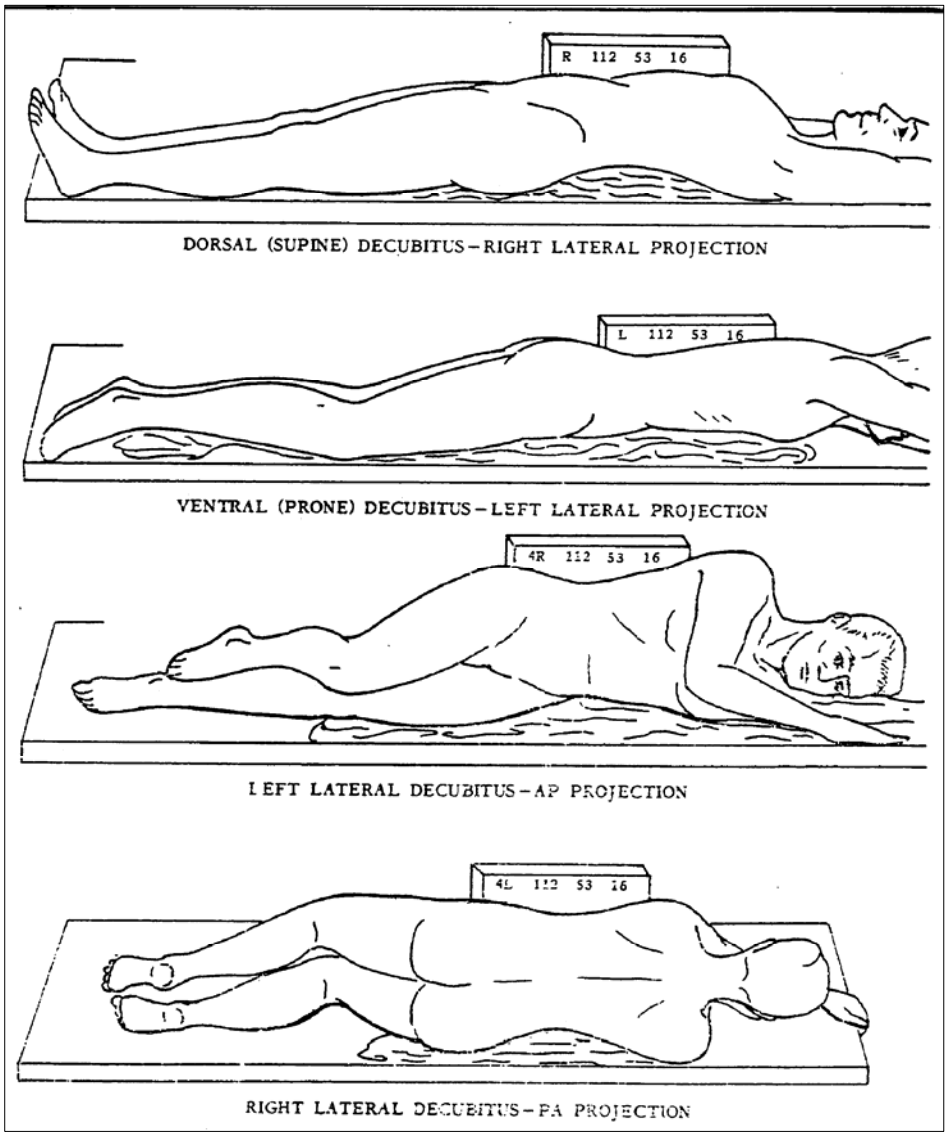

R 112 53 16
DORSAL (SUPINE) DECUBITUS – RIGHT LATERAL PROJECTION
L 112 53 16
VENTRAL (PRONE) DECUBITUS – LEFT LATERAL PROJECTION
4R 112 53 16
LEFT LATERAL DECUBITUS – AP PROJECTION
4L 112 53 16
RIGHT LATERAL DECUBITUS – PA PROJECTION

Figure 2-41. Decubitus position.

2-21. CONSIDERATIONS

It is desirable to see both sides of the patient's body on the film in any given projection of a decubitus position. The affected side MUST be shown with no cut-off. Accordingly, a firm pad, folded blanket or folded sheets should be placed between the table surface and the patient to elevate the dependent side of the patient. If the condition of the patient or other factors makes this elevation inadvisable, the Bucky tray, partially out, may be used as a support for the vertical film holder and a standard wheeled hospital litter with pad used as a table. Allow the patient to remain in position approximately five minutes so the free air rises and/or free fluid moves downward.

2-22. TECHNIQUE

a. The essential position, the reference point for placement of the part, and the technique factors used for a decubitus position should be in keeping with those used for a normal projection of the same area. If an AP projection of the abdomen in a left lateral decubitus position is requested, the crest of the ilia should be centered and the horizontal CR should be directed to the center of the film. In the examination of those parts calling for a grid or Bucky, a portable Bucky or grid cassette should be used.

b. A vertical x-ray table with Bucky used in combination with the standard wheeled hospital litter with pad is an effective combination for decubitus positions. It permits easy handling of the patient and equipment and is usually comfortable for the patient. If a patient is brought to the x-ray department on the wheeled hospital litter, it is often possible to accomplish all necessary film exposures without moving him to the x-ray table and with a radiographic quality close to that possible with table-positioning. This possibility should be kept in mind not only for decubitus positions, but also for emergency and hard-to-work with patients.

2-23. IDENTIFICATION

a. The identification data are usually placed along the lateral border of the cassette corresponding to the side of the body that is uppermost. The letter marked (R or L) indicates the side nearest the film in lateral projections and indicates the side with which it is placed in AP (anteroposterior) or PA projections. In addition to the regular identification data, the following facts should be included:

(1) The type of decubitus position.

(2) The designation of the projection.

(3) The identity of the surface that is up.

b. These added data identify the film unquestionably as a decubitus-type position, making the details on the film more readily recognizable to any film interpreter.

2-24. CLINICAL APPLICATIONS

There are many clinical applications of decubitus positions, although not called by that name. PA right lateral decubitus is a great aid in demonstrations of stones and moving the gall bladder away from the spine in cholecystography. Right and left lateral decubitus positions are used in air contrast barium enemas. In addition, they can demonstrate free air and fluid in chest and abdominal x-rays to rule out damage to thoracic and abdominal structures following trauma, especially, when the patient is unable to stand or sit up.

Continue with Exercises

EXERCISES, LESSON 2

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the question or best completes incomplete statement.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. Fluoroscopic examination of the esophagus is normally started with the patient in what position?

   a. Prone.

   b. Supine.

   c. Erect.

   d. Laterally recumbent.

2. A thick-paste barium sulfate mixture is often used in the radiographic study of the:

   a. Esophagus.

   b. Small intestine.

   c. Stomach.

   d. Large intestine.

3. Radiography of the esophagus almost always includes what position?

   a. Right anterior oblique.

   b. Caldwell.

   c. Lateral decubitus.

   d. Supine decubitus.

4. What is the essential patient preparation order for radiographic examination of the stomach and duodenum?

   a. Cleansing enema 1-2 hours before appointment.

   b. Nothing by mouth for a period of 8-12 hours prior to appointment.

   c. Six telepaque tablets 10-14 hours before appointment.

   d. Laxative 4-6 hours prior to appointment.

5. Ice-cold normal saline solution may be used in place of water as a vehicle for the contrast medium in radiographic studies of the:

   a. Kidneys.

   b. Small intestines.

   c. Aorta.

   d. Gallbladder.

6. When the sigmoid colon is of special interest, a projection may be made with the patient supine, left hip down, right hip and trunk rotated upward _____ to _____ degrees.

   a. 10, 20.

   b. 20, 50.

   c. 30, 60.

   d. 40, 75.

7. To inflate the retention cuff on the double-contrast rectal enema tip, which of the following is used?

   a. Air pump.

   b. Blood pressure bulb.

   c. Multi-Puff Insufflator.

   d. 60 cc syringe.

8. High-kilovoltage spot-filming of the barium-filled colon utilizes what kilovoltage level?

    a. 90-110.

    b. 120-140.

    c. 210-220.

    d. 400 plus.

9. What position should be used for scout films of the gallbladder?

    a. PA.

    b. Left anterior oblique.

    c. Right anterior oblique.

    d. Kirklin.

10. While a gallbladder scout film is usually large, a tightly restricted cone field and a(n) _____ film are usually employed for subsequent projections.

    a. 6x8-inch.

    b. 8x10-inch.

    c. 10x12-inch.

    d. 12x14-inch.

11. Cholangiography is a radiographic study of the:

    a. Gallbladder.

    b. Liver.

    c. Kidneys.

    d. Biliary tract.

12. During intravenous cholecystography, a contrast media is injected into circulatory system to demonstrate the:

    a. Liver.

    b. Pancreas.

    c. Spleen.

    d. Gallbladder.

13. What procedure is the basic functional study of the urinary system?

    a. Instrumental urography.

    b. Retrograde pyelography.

    c. Intravenous pyelography.

    d. Retrograde urography.

14. In which of these procedures would adrenalin most likely be ready for prompt use in case of patient reaction to a contrast medium?

    a. Intravenous pyelography.

    b. Retrograde pyelography.

    c. Small bowel series.

    d. Large bowel series.

15. There is a "split-exposure" technique used in pyelography to differentiate between a ureteral calculus and a calculus-like density. In this procedure, what element does the specialist change between the two exposures?

    a. The film.

    b. The position of the film holder.

    c. The position of the patient.

    d. The position of the x-ray tube.

16. Where is the centering point for an AP view of the urinary bladder?

    a. One inch above symphysis pubis.

    b. Crest of ilium.

    c. Midway between ASIS and crest.

    d. Fifth lumbar vertebra.

17. Suppose that the exposure time for making a cystogram of a certain patient is 6 seconds. Approximately, what would be the exposure time to make a pneumo-cystogram of the same patient?

    a. 3-3.5 seconds.

    b. 6 seconds.

    c. 12-14 seconds.

    d. 24-30 seconds.

18. In routine nephrography, the contrast medium is administered by what route?

    a. Intravenous.

    b. Catheter.

    c. Oral.

    d. Intramuscular.

19. Nephrograms may sometimes result as a side-effect in which of these procedures?

    a. Cholecystography.

    b. Operative cholangiography.

    c. Angiocardiography.

    d. Retrograde pyelography.

20. A urethrogram is exposed with the film centered at the interior border of the:

    a. Eleventh rib.

    b. Anterior-superior iliac spine.

    c. First lumbar vertebra.

    d. Symphysis pubis.

21. To take a hysterosalpingogram, the film is centered at the:

    a. Symphysis pubis.

    b. Symphysis menti.

    c. ASIS.

    d. Coccygeal tip.

22. Approximately what quantity of carbon dioxide or oxygen is introduced for a pelvic pneumoperitongeogram?

    a. 2 cc.

    b. 30 cc.

    c. 100 cc.

    d. 500 cc.

23. In making a pneumoperitongeogram, how would technique factors be changed from the technique used in normal radiographs of the same region?

    a. Increase the kilovoltage.

    b. Decrease the SID.

    c. Decrease the mAs.

    d. Increase the SID.

Check Your Answers on Next Page

SOLUTION TO EXERCISES: LESSON 2

1. c (para 2-2c(3))
2. a (para 2-2b(3))
3. a (para 2-2d(1))
4. b (para 2-3a(1))
5. b (para 2-4)
6. c (para 2-63(3)(c))
7. c (para 2-6c(3)(e))
8. b (para 2-5c(4))
9. a (para 2-7b(1))
10. b (para 2-8a(5)(a))
11. d (para 2-9)
12. d (para 2-8)
13. c (para 2-10b)
14. a (para 2-11e(1)(d))
15. d (para 2-12c(9))
16. a (paras 2-13d(1), (4))
17. a (para 2-13d(6))
18. a (paras 2-14b, c(4))
19. c (para 2-14c(9))
20. d (para 2-16d(4))

21. c (para 2-17c(2))

22. d (para 2-17c(9))

23. c (para 2-17c(9))

End of Lesson 2

LESSON ASSIGNMENT

LESSON 3	Respiratory, Cardiovascular, and Nervous Systems.
TEXT ASSIGNMENT	Paragraph 3-1 through 3-31.
LESSON OBJECTIVES	After completing this lesson, you should be able to:
	3-1. Choose proper radiographic and fluoroscopic procedures involving the respiratory system.
	3-2. Choose proper radiographic and fluoroscopic procedures involving the cardiovascular system.
	3-3. Choose proper radiographic and fluoroscopic procedures involving the nervous system.
SUGGESTION	After completing the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 3

RESPIRATORY, CARDIOVASCULAR, AND NERVOUS SYSTEMS

Section I. THE RESPIRATORY SYSTEM

3-1. INTRODUCTION

Advances in technology take place every day. The bronchographic studies are being used less and less, replaced by other modalities. Computed tomography is used primarily, as well as pulmonary angiography, nuclear medicine, and magnetic resonance imaging. These are now the preferred modalities for imaging the respiratory system. Of all the organs and structures that comprise the human body, the lungs are most frequently examined by radiologic means. The major components of the respiratory system are generally demonstrated via standard PA (posterior-anterior) and lateral chest projections. However, certain respiratory diseases and bronchial conditions require detailed examination of the bronchial tree before a definite diagnosis can be made. The radiographic study of the bronchial structures using a contrast medium is called bronchography. Computed tomography is the modality of choice and has replaced bronchography.

3-2. ALTERNATIVE MODALITIES OR PROCEDURES

a. **Computed Tomography (CT).** CT is most frequently used to examine and identify masses or other pathology in either the mediastinum or in the lung.

b. **Bronchography.** CT is the modality of choice and has replaced bronchography. Bronchography, performed in the past to examine the bronchial tree and lungs after introduction of a catheter and positive contrast media into the bronchi (see figures 3-1 through 3-5). PA, lateral, and frequently obliques were then taken to rule out pathologies such as obstructions, fistulas, carcinoma, bronchitis, or bronchiectasis.

c. **Sonography (Ultrasound).** Ultrasound may be used to detect pleural effusion (fluid within the pleura space) or for guidance when inserting a needle to aspirate the fluid (thoracentesis).

d. **Nuclear Medicine.** Certain nuclear medicine procedures involving radionuclides can be used to evaluate and diagnose pulmonary diffusion conditions or pulmonary emboli.

e. **Magnetic Resonance Imaging (MRI).** Cardiovascular MRI procedures can be used to demonstrate and evaluate certain pathology such as congenital heart disorders, graft patency, cardiac tumors, thrombi, pericardial masses, and evaluation of aortic dissection and aneurysms.

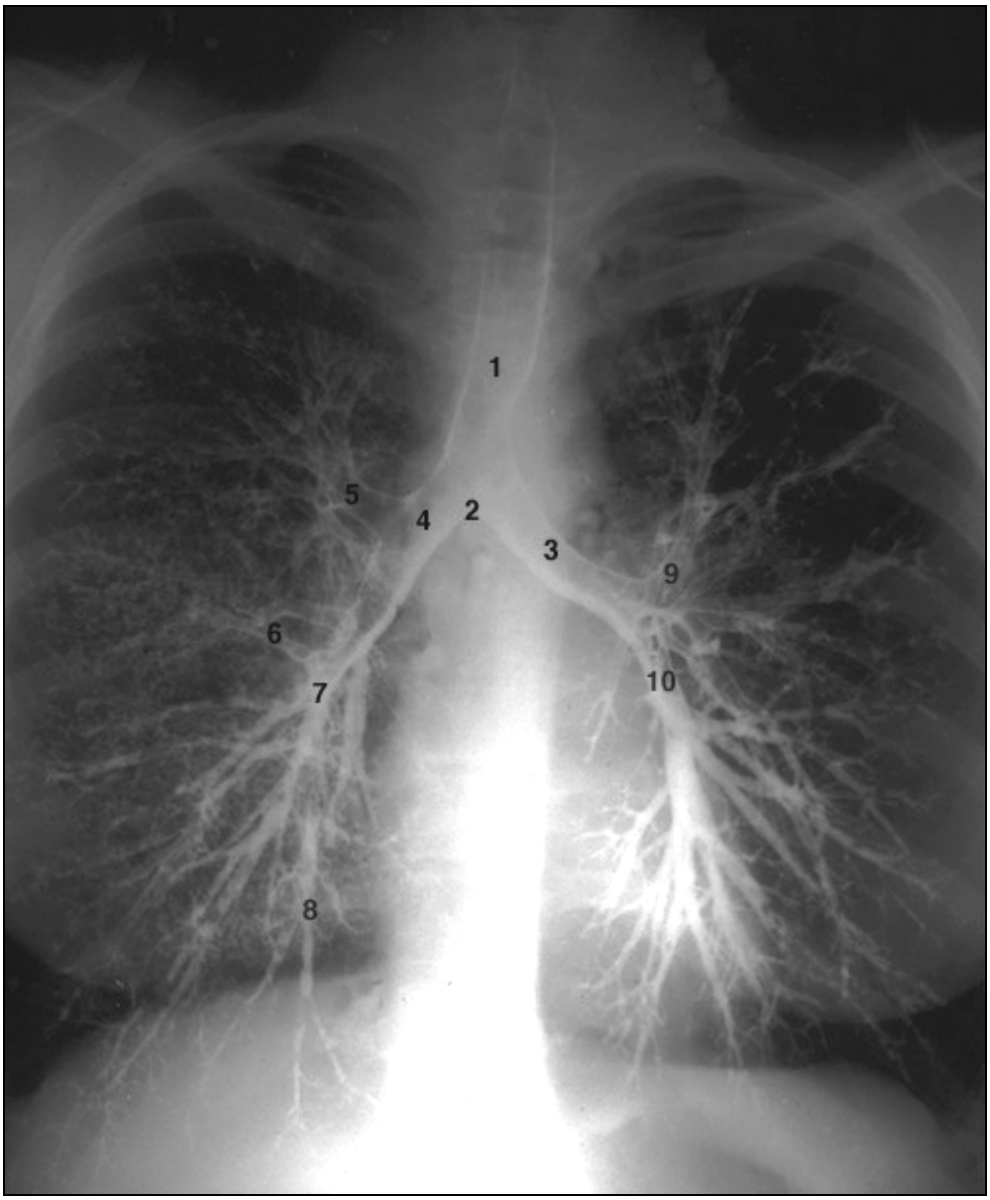


Figure 3-1. Bronchogram, PA.

1. Trachea	6. Right middle lobe bronchus
2. Carina	7. Right lower lobe bronchus
3. Left main bronchus	8. Bronchus to segment of right lower lobe
4. Right main bronchus	9. Left upper lobe bronchus
5. Right upper lobe bronchus	10. Left lower lobe bronchus

Figure 3-2. Bronchogram, PA right oblique.

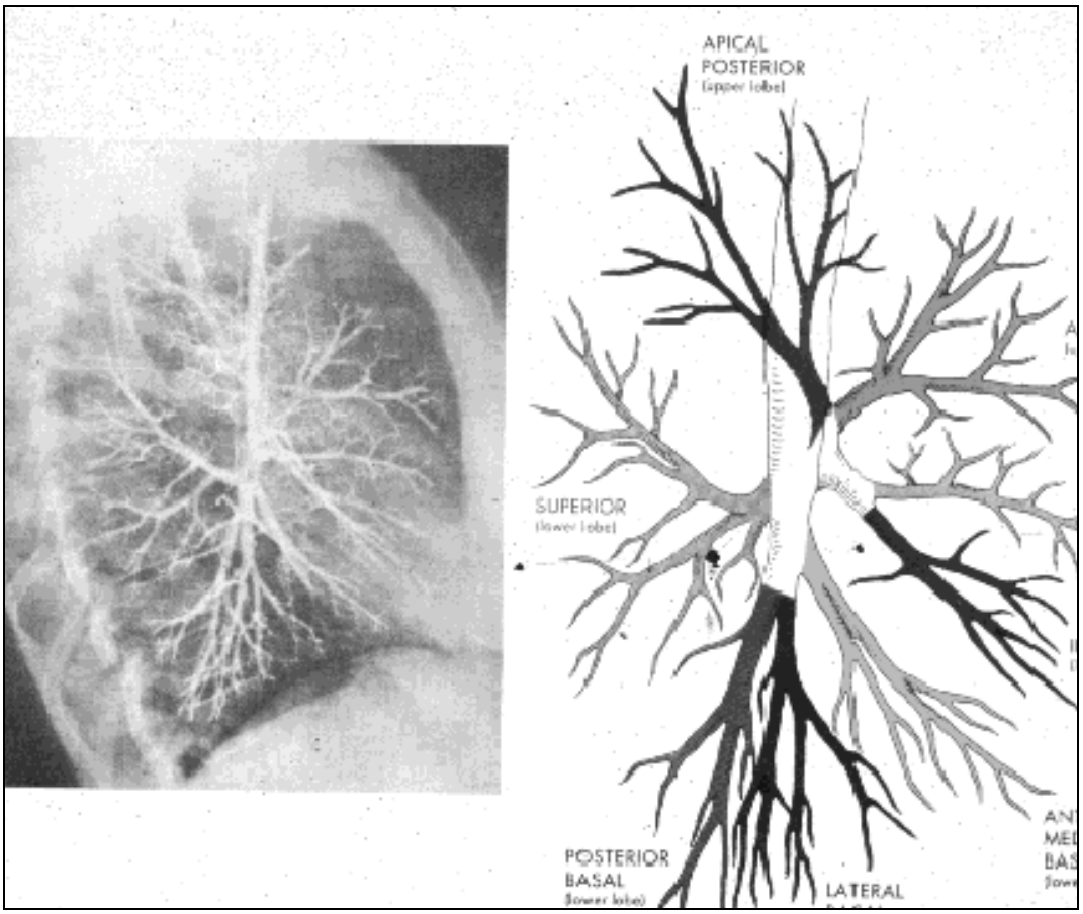


Figure 3-3. Bronchogram, left lateral.

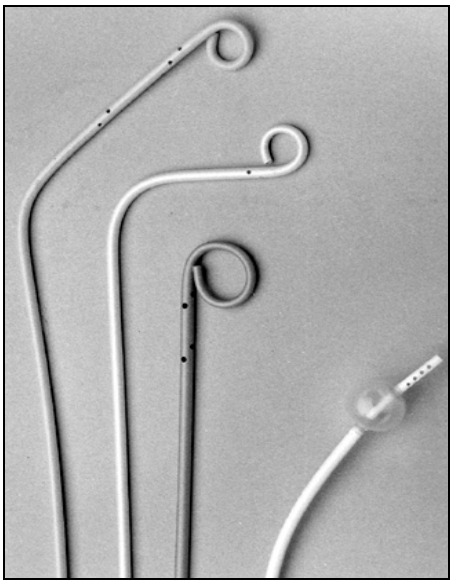
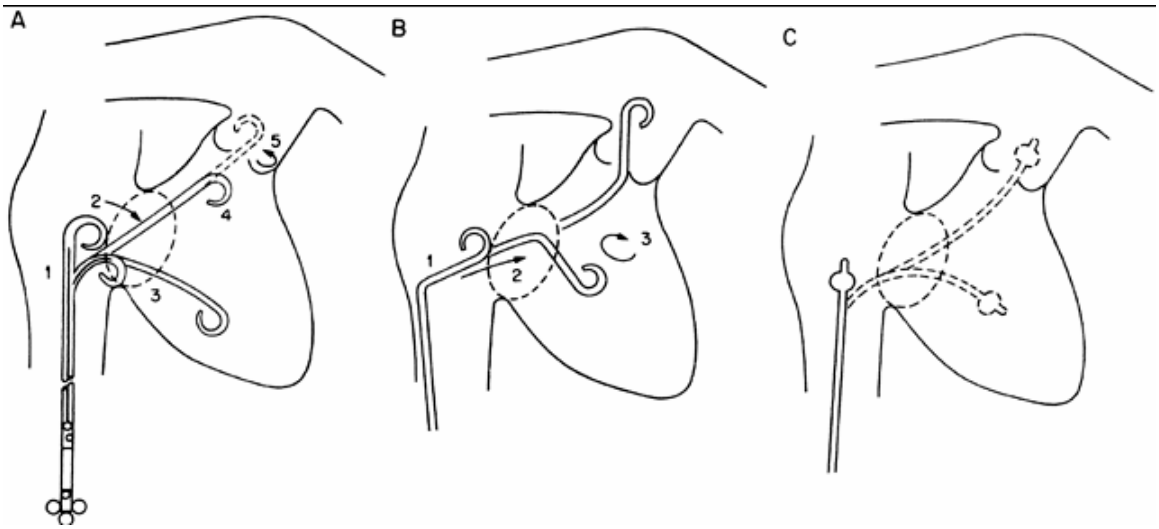


Figure 3-4. Catheters for pulmonary angiography.
Left to right: the Nyman, Grollman, and straight pigtail catheters, and the balloon occlusion with side-holes distal to the balloon (Berman type).



(A) Straight body pigtail catheter and tip deflecting wire. (1) The pigtail catheter is placed in the right atrium. (2) The wire is deflected to point toward the right ventricle. (3) The wire is fixed, and the catheter is advanced over it into the right ventricle. (4) The tip deflection is released. (5) Counterclockwise rotation of the catheter swings the pigtail anteriorly. Simultaneous advancement of the catheter places it into the main pulmonary artery. Advancing the catheter further usually takes it into the left main pulmonary artery. The tip deflecting wire is utilized to direct the catheter downward and to the right for right main pulmonary artery catheterization.

(B) Angled pigtail catheter. (1) The pigtail catheter is place in the right atrium. (2) Advancing the catheter places the tip in the right ventricle. (3) Clockwise rotation, with simultaneous advancement places the tip in the main pulmonary artery.

(C) Balloon catheter. The balloon is inflated under fluoroscopic guidance in the common iliac vein. It is advanced under observation through the right heart and into the main pulmonary artery. Selection of right and left pulmonary arteries is assisted with conventional or tip-deflecting wires. If a pigtail catheter is needed after use of a balloon catheter, 260 cm Rosen wire is used for the exchange.

Figure 3-5. Techniques for pulmonary artery catheterization.

Section II. THE VASCULAR SYSTEM

3-3. INTRODUCTION

a. Angiography (or vasography) is the radiographic investigation and study of the blood channels in selected portions of the circulatory system after injection of a radiopaque contrast medium to render them visible. Images are captured with digital fluoroscopy and digital printers are capable of printing multiple images on each film. The unprinted digital image is still available on the image archiving system. There are three basic divisions of angiography.

NOTE: Many examinations of the vascular system are now replaced by other modalities such as computerized tomography (CT) and magnetic resonance imaging (MRI).

(1) Arteriography. Arteriography is the radiographic examination of the arteries during injection of a radiopaque contrast medium.

(2) Venography. Venography (or phlebography) is the radiographic examination of the veins during the injection of a contrast medium. Venography may be done in one of two ways. In direct venography, the contrast medium is injected directly into the lumen of the veins and radiographs are exposed the instant a given portion of the venous system is filled with the contrast medium. In direct venography, the contrast medium is introduced into a selected portion of the arterial system and radiography of the analogously related venous channels is done at the time the contrast medium is passing through the veins on its return flow.

(3) Capillariography. Capillariography is the radiographic examination of the capillaries after they have been filled with a contrast medium (nephrography is a form of capillariography).

b. The terms below apply to specific types of angiographic examinations.

(1) Angiocardiography. Angiocardiography is the radiographic examination of the heart and great vessels of the thorax during the venous injection of an opaque contrast medium.

(2) Aortography. Aortography is the radiographic examination of the aorta after injection of a contrast medium.

(3) Cardiac catheterization. Cardiac catheterization is a procedure wherein a catheter is introduced into the heart via selected blood vessels under fluoroscopic control to obtain samples of blood from the various chambers of the heart for determination of the cardiac output.

(4) Selective catheterization or direct angiography. This is a procedure wherein a contrast solution is introduced directly into specific chambers of the heart of particular blood channels (via a catheter in vivo) and the structures are x-rayed during radiopacification.

(5) Cerebral arteriography. Cerebral arteriography, also known as arterial encephalography or cerebral angiography, is the radiographic visualization and study of the intracranial arterial channels during induced radiopacification.

(6) Intra-osseous venography. Intra-osseous venography is a special procedure for the radiographic investigation of selected venous pathways during radiopacification following the introduction of a contrast medium via the intramedullary or intraspongious route.

(7) Portal venography. Portal venography is the radiographic examination of the venous circulation in the spleen and related blood channels during induced radiopacification.

3-4. THE X-RAY SPECIALIST'S ROLE

The x-ray specialist must have an integrated concept of the essential elements and procedural mechanics common to the most frequent angiographic examinations. The importance of this cannot be overemphasized. Only the basic elements of the techniques in the different procedures are described. All of these procedures are subject to variation since each patient undergoing an angiographic examination is regarded as a special case. Except in emergencies, all angiographic examinations are scheduled in accordance with the established clinical procedure.

NOTE: To broaden his knowledge, the specialist should refer to pertinent texts and professional journals dealing with angiography.

3-5. PATIENT PREPARATION

a. **Premedication.** Premedication of the patient will depend upon clinical dictates.

b. **Control of Eating and Drinking Prior to the Examination.** This is governed largely by the type of examination and the judgment of the examiner.

c. **Check Laboratory Results.** Check laboratory results for blood urea nitrogen (BUN), creatinine (Cr), hemotocrit /hemoglobin (Hct/Hgb), prothrombin time (PT), partial thromboplastin time (PTT), platelets, etc. The values are checked to determine any possible reaction to iodide compounds even though non-ionic contrasts are primarily used.

d. **Anesthesia.** Local anesthesia is usually administered by the examiner. If general anesthesia has been administered, the patient will be unable to control his respiration or cooperate in assuming or maintaining certain positions.

e. **Preparation of the Intended for Injection.** The injection site is prepared by the examiner or by a designated individual under his direct supervision, usually just prior to making the injection.

3-6. SOLUTIONS

The principal solution is the contrast-producing agent. Usually, this consists of one of the sterile aqueous solutions of 60 percent to 76 percent diatrizoate meglumine injection, or iotalmate injection. The choice of an intravascular contrast agent depends on its opacity, osmolality, viscosity, lack of toxicity, and expense. The substitution of meglumine (methylglucamine) for most or all of the sodium of the earlier tri-iodized contrast compounds has resulted in greater patient comfort and less induced, localized, and systemic absorption. The contrast solution must be clear of sediment, sterile, and (unless otherwise specified) maintained at body temperature prior to examination. In some instances, the specialist may be required to fill the syringe(s) with the contrast solution. It is imperative that he use sterile technique and make certain that the right solution goes into the right syringe. This is of vital importance.

NOTE: There are many other types of contrast-producing agents. Consult a practicing radiologist for the desired types of contrast-producing agents.

3-7. MATERIALS AND APPARATUS

These items are frequently made up into special sets or layouts for specific procedures (for example: angiocardiography, venography of the lower extremities, cardiac catheterization). Representative items in this category may include any of the following.

a. **Syringes.** Luer-lok type, number and sizes are required.

b. **Needles.**

(1) Needle-stopcock unit, type suited to the particular requirements or the preference of the examiner.

(2) Needles of the particular gauge, length, or design for solution transfer.

(3) Hypodermic needles.

c. **Tubing.** Sterile pieces of tubing are required in suitable calibers and lengths.

d. **Flow Switch.** This is a device attached at the end of the tubing that allows the examiners to stop the back-flow of contrast once contrast injection has stopped.

e. **Catheters.** Fascial dilators are used to slowly expand the access site. There is a wide range of sizes from 4.5 to 28 French. They should be readily available during the procedure.

f. **Sterile cups.** The projected number needed of sterile cups should be included.

g. **Forceps.** Sterile forceps are included in the type(s) and size(s) needed.

h. **Scalpel.** A sterile scalpel and blades are laid out in the size and number required.

i. **Towels and Drapes.** Sterile towels and drapes should be included.

j. **Gloves and Gowns**. A supply of sterile gloves and gowns will be needed.

k. **Gauze Squares.** Include sterile gauze squares in sizes likely to be needed.

l. **Tourniquet.** Lay out a tourniquet, adhesive tape, and bandage.

m. **Table.** Be sure there is a table or instrument stand for arranging layouts.

3-8. SPECIAL ANGIOGRAPHIC EQUIPMENT

a. **Needles.** There are many styles of needles employed for angiography. Some are listed and described below.

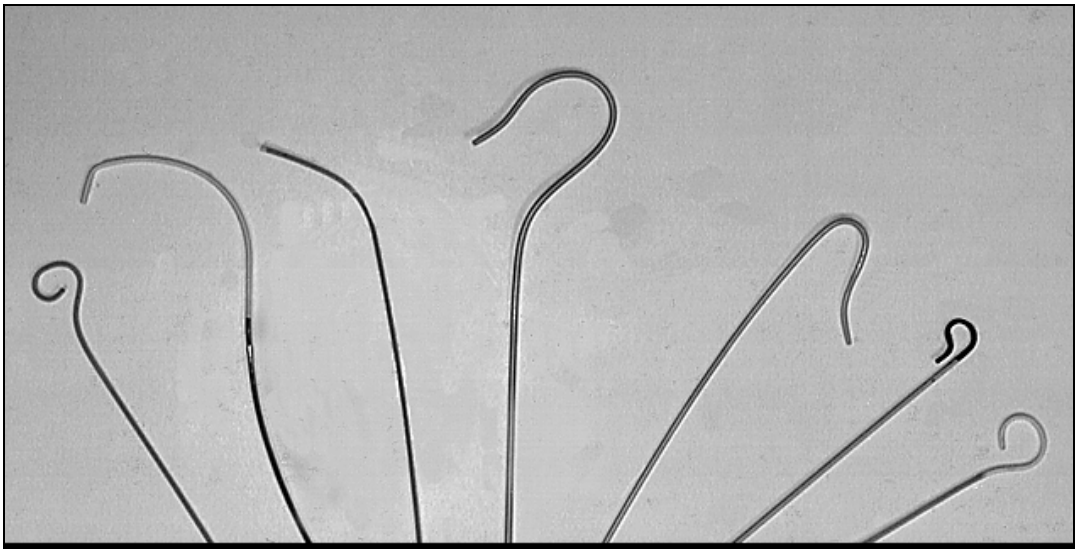
(1) The venipuncture needle has the sharpest bevel of the needles employed. It is very satisfactory for percutaneous vein puncture; however, its sharpness is a disadvantage with arterial puncture because of the danger of making too deep an insertion.

(2) The arteriographic needle, such as the Seldinger style, has a protruding obturator with a low profile bevel and central stylet. It is designed to be inserted when assembled. Most modern arteriographic needles have a blunt tip with a sharp protruding obturator and matching protruding blunt obturator. The advantage of this needle is that the lumen of a vessel can be identified by the flow of arterial blood once the central stylet is removed. The blunt obturator can then he reinserted, restricting the flow of blood.

(3) Sheath needles are a variation on the arteriographic design with a flexible plastic sheath fitted over the needle slightly shorter than the bevel. Once the lumen is encountered after insertion, the needle is withdrawn and the sheath remains. This can be threaded into the vessel. The needle should not be reinserted into the sheath except under direct vision since the needle can cut the plastic sheath.

b. **Catheters.** If a catheter is to be introduced, the decision as to type will be made by the examiner. The first cardiac catheters were an adaptation of ureteral catheters. A relatively thin-walled, more supple design was forthcoming. There are many different types and shapes of catheters. The barium-loaded polyethylene catheter (ductile and malleable in water, steam, or air at 75ºC) allows the operator to readily form a tip design and catheter shape or change design to fit the anatomic circumstances (see figure 3-6). Factory preformed catheters are available in sterile disposable form. This type of catheter will perform ninety percent of clinical angiographic studies. Table 3-1 shows characteristics of some of the available catheter materials.

c. **Injection Apparatus.** An automatic injection apparatus is used. The automatic type is set and can be adjusted to control the rate of injection and automatically initiate the exposure at a predetermined time after the commencement of the injection.



Left to right: Pigtail, cobra, multipurpose, headhunter, Simmons, SOS-OMNI, tennis-racquet.

Figure 3-6. Peripheral angiographic catheters.

	Polyurethane	Polyethylene	Polyvinyl	Teflon	Metal Braid
Friction of usual finish	Low	Medium	Medium	Medium	Medium
Curve retention	Excellent	Good	Good	Excellent	Good
Kinking tendency	Moderate	Low	Low	Very Low	Low
Torque response	Good	Fair	Fair	Excellent	Good
Resistance to bursting pressure	High	Moderate	Moderate	High	High
Effect of temperature and moisture of the blood on flexibility	None	Minimal Increase	Moderate Increase	None	None
Sterilization	Autoclave	Cold	Autoclave	Cold	Cold

Table 3-1. Comparison of various catheter materials.

3-9. RADIOGRAPHIC EQUIPMENT

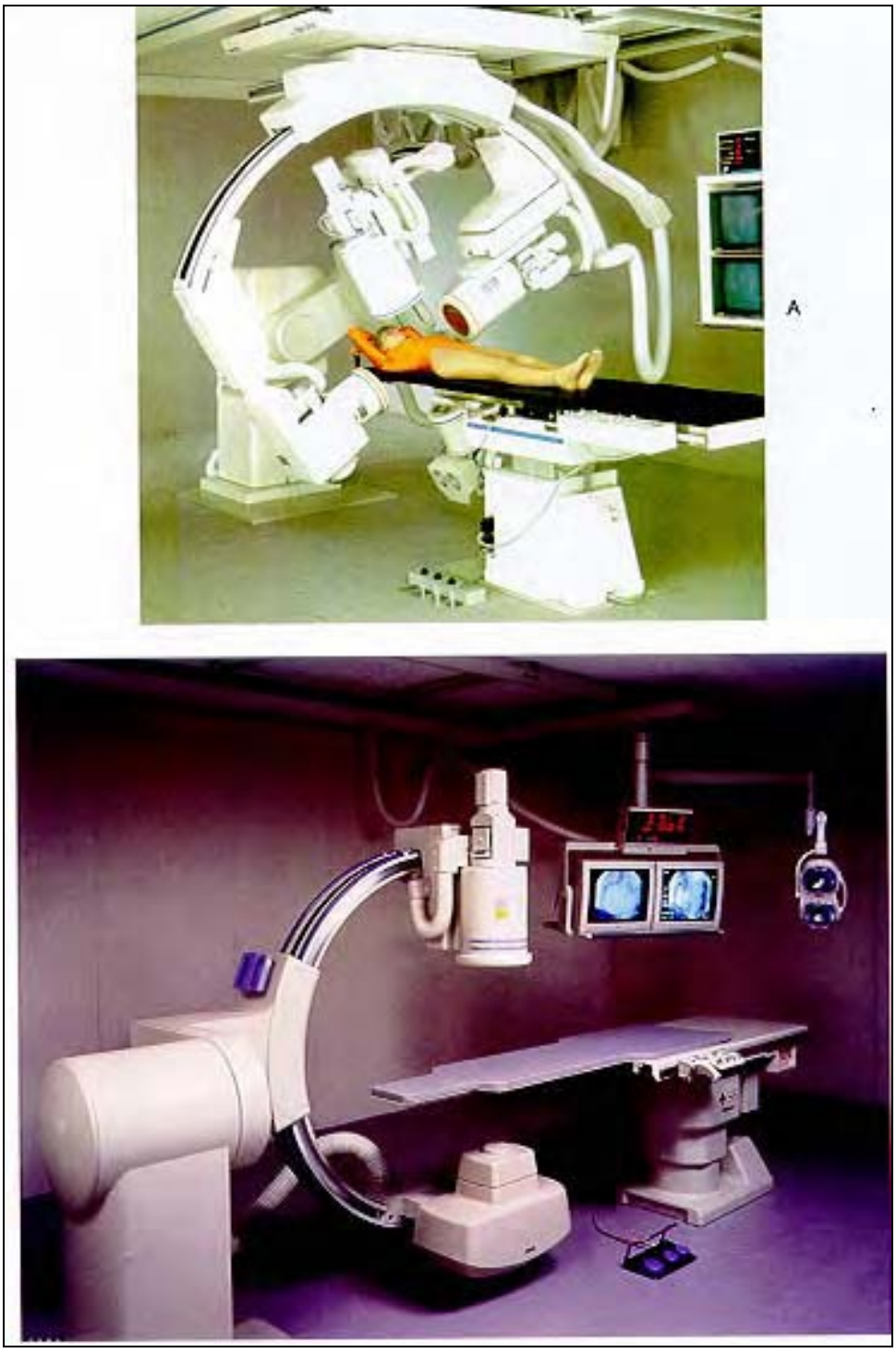
a. **Type of Equipment Used for Direct Radiography.**

(1) Stationary (combination radiographic-fluoroscopic or non-fluoroscopic) or mobile conventional x-ray unit.

(2) Multiple C-arm setup hooked up with digital image capturing and archiving system rapid exposures. See figure 3-7.

(3) Two-tube setup, the most common, with simultaneous biplane exposure apparatus hooked up with a digital image capture system; however, rapid cassette-changing devices are still used.

(4) Two-tube setup equipped with apparatus for making rapid-sequence, biplane, and capturing the images digitally. For older systems, a synchronized exposure on a large roll film is still used.



A. Biplane radiology equipment used in the cardiac catheterization laboratory.
B. Modern single-plane digital catheterization with “smart handle” technology.

Figure: 3-7. Equipment used for direct radiography.

b. **Type of Equipment Used for Indirect Radiography or Photofluorography.** For this method, digital subtraction images are captured and the x-ray unit is equipped with a digital image intensifier.

c. **Tube Heat Capacity.** This factor is of prime importance in angiography, especially when it is necessary to make rapid-sequence exposures of very short duration (1/30 sec (second) or less) and relatively high energy levels. Tube and generator capacities from 300 to 1200 mA are commonly used in angiocardiographic examinations. When relatively high milliamperage values are used, careful consideration must be given to the appropriate tube-rating chart. For example, if the tube-rating chart stipulates an upper limit of 1/10 second exposure time at 500 mA and 100 kVp, this would permit six rapid-sequence exposures at 1/60 second, or three such exposures at 1/30 second. This means that the sum of any serialized increments of exposure time (in rapid sequence) is not to exceed the safe limits stipulated in the tube-rating chart for the given mA-kVp value. Where it is not feasible to use the upper range of mA values, the lower mA values, with compensatory increase in kVp, may be used.

d. **Accessory Devices.**

(1) Grid-front cassettes or tape-on grid mounted on a movable stand that can be adjusted.

(2) Protective devices especially designed for, or easily adaptable to, the particular needs of the given situation, such as leaded shields, lead-impregnated gloves and aprons, and thyroid shields. These items are required for the protection of all personnel against direct or stray radiation.

(3) Special timing and sequencing device (or program selector). This may consist of a thyraronic rapid-recovering timing unit or a timing unit that embodies a type of high-voltage switch, tube, and condenser arrangement. These devices are used for making exposures of 1/1000 to 1/500 second in rapid sequence at predetermined intervals. They are especially suited for serialized studies showing the progressive phases of the transport of the opacifying agent through specific portions of the vascular system (for example, the various chambers of the heart or the great vessels).

(4) Immobilization and supportive devices, such as bands and straps, clamps, bags filled with sand or shot, folded towels, adjustable stools, and foot and shoulder rests.

3-10. POSITION OF PATIENT

a. **Position of Patient During Injection of the Contrast Medium.**

(1) The position is determined by the examiner. The decision will be influenced by the nature or type of examination, the condition of the patient, the preferred methodology of the examiner, the nature and extent of any existent or suspected pathology and/or anomaly, and the degree of adaptability of the available equipment.

(2) Before starting the procedure, the examiner tells the specialist whether the patient is to be placed in the supine, prone, sitting, standing, or lateral (right or left) decubitus position for the injection. Strict attention on the part of the specialist concerning this point cannot be overstressed. The technique is exacting and demands perfect coordination and timing; following the injection, there is only a very short interval in which to maneuver the necessary equipment into place, adjust controls, and (if necessary) change the position of the patient or part for the exposure.

(3) In some instances, angiographic examinations have to be conducted without a preplanned or set routine. The specialist must be constantly on the alert as the examiner will give impromptu or "on-the-spot" directions.

b. **Position of the Patient During Exposure of Angiograms.** The examiner may have the patient remain positioned as for the injection procedure or he may have him placed in a different position for the radiography.

3-11. SITE OF INJECTION

a. The site of injection is selected by the examiner. The site selection will depend upon such factors as the specific portion of the blood channels under examination, the existent or suspected pathology, the type of procedure, and the preference of the examiner.

b. If possible, the position of the patient should be oriented so that the site of injection will be same as the working side of the table.

c. If the venous channels of an extremity are injected, the position of the film, with respect to the part, should be adjusted so that maximal coverage will be obtained of those structures that lie distal to the injection site.

3-12. METHOD OF INJECTION

Determined by the examiner, the injection may be made by the percutaneous method or by the insertion of a needle, cannula, or catheter into a selected blood vessel after surgical exposure and under local or general anesthesia. If a special injection apparatus is used, the specialist should anticipate moving the apparatus into position, checking out the electrical connections, disassembling and cleaning the apparatus after usage, and similar tasks.

3-13. RATE OF INJECTION

Since time is an all-important factor, the rate of injection ties in with the need for working out in advance signals or cues for making each desired exposure at the optimal instant. For example, when a relatively large amount of contrast solution (usually of a heavy concentration) is rapidly injected into the aorta, a delay of even one second in making the exposure may render the projection valueless.

3-14. USE OF A TOURNIQUET

A tourniquet is used by many examiners, especially in examinations of the extremities, to force the contrast agent into the deeper blood channels. The specialist must be very careful while adjusting the position of the patient or exchanging cassettes for serialized exposures to make sure that he does not disturb the tension of the applied tourniquet or cause it to snap loose.

NOTE: In some instances, an inflatable cuff may be used in lieu of the customary rubber tubing.)

3-15. PROJECTIONS

The projections to be taken for any specific examination are determined by the examiner, usually at the time the examination is begun. It is necessary for the specialist to know:

a. What projections are to be made (for example: AP, lateral, oblique).

b. What area or areas are to be included in given projections.

c. Number of films to be exposed per projection and the time interval between exposures.

d. How the patient is to be positioned for stereoscopic exposures, if indicated.

3-16. SIZE OF FILM

Images are captured with digital fluoroscopy. Digital printers are capable of printing multiple images on each film. In addition, the unprinted digital image is still available on the image archiving system. In selecting the size of film, the following factors must be considered:

a. The particular region to be radiographed and the extent of coverage desired.

b. The size of the patient. In an angiocardiographic examination, for example, an 8 x 10-inch film may suffice for an infant, but a large film (usually 14 x 17-inch) would be required for an adult.

3-17. THE CR

a. If, in a given situation, the subject to be radiographed is placed in a specified position with the objective of accomplishing a certain radiograph, the projection can be made only according to the following CR relationships:

(1) With the CR directed from a vertical relationship.

(2) With the CR directed from a horizontal relationship.

b. Assume, for example, that the patient is in the supine position on the x-ray table and it is desired to obtain AP and lateral projections of the leg with the position of the patient and the part remaining unchanged throughout the procedure. This necessitates the use of two types of CR projections: a vertical CR projection for the AP and a horizontal CR projection for the lateral. However, if the patient is in the standing position and the same projections (AP and lateral) are required, a horizontal CR projection must be used in each case.

3-18. RADIOGRAPHIC EXPOSURE FACTORS

a. As a general rule, the exposure technique for angiographic examinations will require an increase of about 10 percent over the kVp values normally used for comparable radiographs in routine radiography. The mAs values should be adjusted to produce the desired film density. The shortest practicable exposure times should be used.

b. The exposure technique is vital to the success of the examination. Nothing must be taken for granted. If there is the slightest doubt regarding the technique factors (for instance, if the patient is above or below average in size), a test or control film should be exposed and developed prior to the injection of the contrast medium. In this connection, it is extremely important that the specialist have a sound working knowledge of conversion factors. This might include such things as changes from non-grid to grid technique or vice versa, or compensating for changes in SID or mAs-kVp relationships.

3-19. ANGIOGRAPHIC EXAMINATION OF THE UPPER EXTREMITIES

a. **Arteriography.**

(1) Patient preparation and administration of sensitivity test. This is covered earlier in this section (para 3-5).

(2) Preliminary procedure.

(a) After ascertaining whether the right or the left extremity is to be examined, the specialist will adjust the patient in the supine position on the x-ray table, with the arm abducted and supinated.

(b) Images are captured with digital fluoroscopy with new digital printers printing multiple images on each film. The unprinted digital image is still available on the image archiving system.

(c) The groin is the site most frequently used for injection. The actual site depends upon two factors--a strong presence of a pulse and the presence of any vessel disease.

(d) The site of injection is rendered aseptic and from 1 to 2 cc of 0.5 percent procaine solution is injected into the skin and subcutaneous tissues over the site.

(e) From 10 to 15 cc of the contrast solution is warmed to body temperature and placed in the syringe.

(3) Injection of contrast medium and radiography.

(a) The specialist selects the radiographic, technique factors and adjusts the controls of the x-ray unit. Normally, routine (nongrid) factors for the part will suffice, but the exposure time should be as short as possible. With everything in readiness, the specialist assumes the "Ready" position so that the exposures can be made without delay when the examiner gives the signal.

(b) The groin is the most common access site. The contrast is injected and the first exposure is made when the examiner gives the signal. The patient should have been instructed beforehand to remain absolutely motionless at the time the exposure is being made.

(c) For additional exposure, the procedure described above is repeated.

(4) Variations.

(a) When specific or localized areas of the extremity are the objects of clinical interest (for example, a given region of the hand or forearm), pronation of the part may be indicated. Lateral projections may also be included.

(b) Rapid-sequence exposures may be made if the necessary apparatus is available.

(c) A collateral result of arteriography is sometimes achieved by delaying the time of exposure so that the contrast medium enters the analogously related venous channels on its return flow (indirect venography).

(5) Precautions.

(a) Since the examiner usually works in close proximity to the field of exposure, proper safeguards must be employed for his protection; for example, a leaded screen positioned near the x-ray table will provide a relatively safe shelter during the time the films are being exposed. Collimation should be used to keep the field of irradiation within the necessary limits.

(b) A technical difficulty frequently encountered is the mistiming of the exact instant of exposure. Perfectly coordinated teamwork is vitally important to the success of the examination.

b. **Venography.** See figure 3-8.

(1) Patient preparation and administration of sensitivity test. These have been covered earlier in this section (para 3-5).

(2) Preliminary procedure.

(a) As soon as the patient is received at the x-ray clinic, the specialist will ascertain from the examiner the site of injection and the particular portion of the extremity to be examined.

(b) The patient is adjusted in the supine position on the x-ray table, with the arm abducted and supinated.

(c) If the examination is localized to any specified region lying distal to the proximal third of arm, again digital images are captured and digital subtraction is applied to the images.

(d) If the object of the examination is to demonstrate the venous channels of the upper portion of the arm, axillary, shoulder girdle, or upper thoracic regions, then the position of the patient should be adjusted in relation to the midline of the x-ray table so that the desired coverage will be obtained. Digital subtraction images are captured. Identification markers are preferably placed on the tabletop.

(e) The site of injection is rendered aseptic and local anesthesia is administered.

(f) The injection needle is then inserted into a vein (for example, the antecubital vein or the basilic vein for views of the hand).

(3) Injection of contrast medium and radiography.

(a) From 20 to 40 cc of the contrast solution, similar to that used for arteriography, is injected at a rate of from 5 to 20 cc per second.

(b) When given the signal by the examiner, the specialist makes the first exposure. The exact time at which this exposure is made may vary from the instant the injection is completed to 5 or more seconds afterwards.

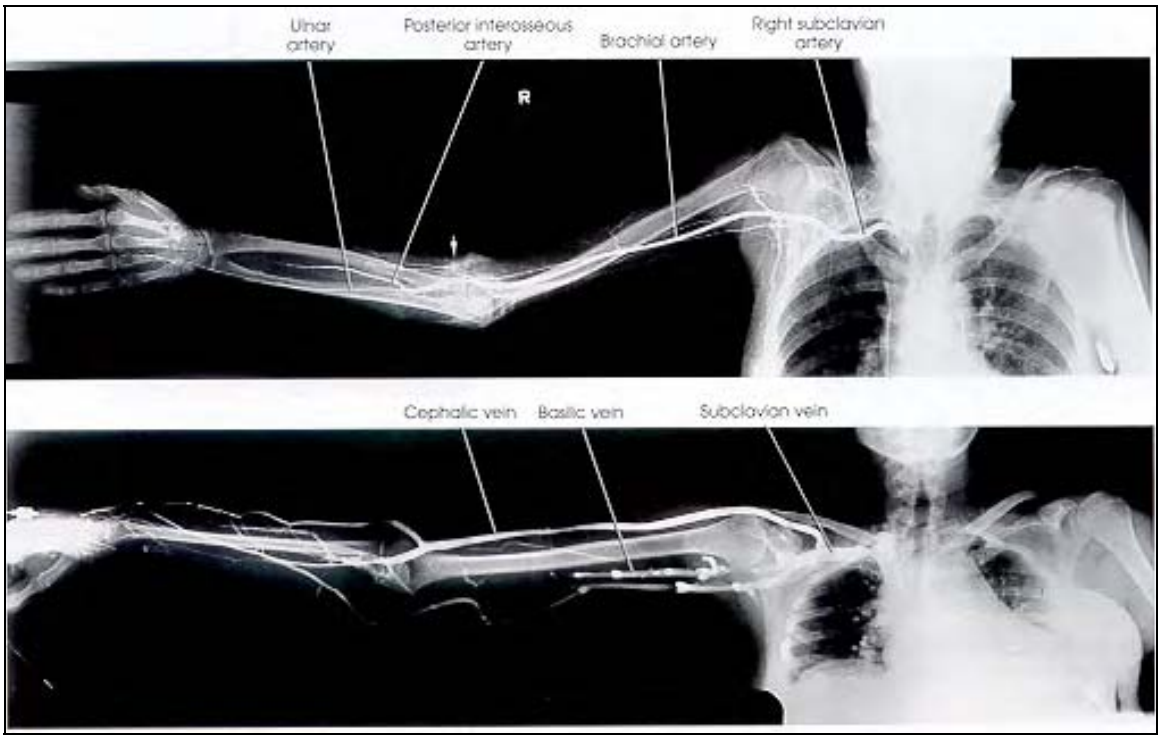
(c) Additional exposures are made by direction of the examiner.

(4) Control of respiration during exposure of films.

(a) In some cases, the patient may be instructed to suspend respiration while the exposure is made. In other cases, he may be allowed to breathe naturally.

(b) Under certain conditions, special methods of respiration control may be employed. For example, the patient may be instructed to inhale against the closed glottis (Muller's maneuver) or to execute forced expiration against the closed glottis (Valsalva's maneuver) while the exposure is being made.

(5) Digital subtraction radiography. Digital subtraction radiography is used with automatic exposure control. With digital technology, a highly sophisticated computer “subtracts” or removes certain anatomic structures so that the resultant image demonstrates only the vessel(s) of interest containing contrast media. A subtracted image appears as a reversed image and may visualize diagnostic information not apparent on a conventional non-subtracted image.



The top projection demonstrates the right subclavian artery injected, demonstrating iatrogenic occlusion of radial artery (arrow).

The bottom is a normal right upper venogram.

Figure 3-8. Venography.

3-20. ANGIOGRAPHIC EXAMINATION OF THE LOWER EXTREMITIES

a. **Arteriography.**

(1) Preparation. Digital subtraction is used to demonstrate any part of the lower extremity. Patient preparation and administration of sensitivity test is covered earlier.

(2) Preliminary procedure.

(a) As soon as the patient is received at the x-ray clinic, the specialist will ascertain from the examiner the area(s) of the extremity to be examined. If the examination is concerned with any part lying distal to the region of the knee, then non-grid technique is normally employed. Bucky technique may be indicated when the arterial channels in the thigh region (exclusively) or in the leg and thigh regions are to be examined. With the latter, it is possible to obtain simultaneous coverage of both the leg and thigh portions with a single exposure, by using several cassettes (placed end-

to-end with their adjacent edges overlapping) or by the use of a special 36-inch cassette adjusted underneath the part. When full-length coverage is required, it may be necessary to increase the normal SID to accommodate the area of interest to the exposing x-ray beam. To equalize the exposure between the thinner region of the leg and the thicker region of the thigh, the x-ray tube should be positioned with the cathode end toward the thigh. The use of a compensating filter should also be considered.

(b) The patient is assisted onto the x-ray table, and the lower extremity under consideration is adjusted to the AP position. A 14- x 17-inch cassette is placed beneath the extremity and centered to the region to be examined if nongrid technique is used. With grid technique, the cassette is placed in a Bucky tray and the part or area under consideration is aligned to the midline of the x-ray table.

(3) Injection of contrast medium and radiography.

(a) After the administration of local anesthesia, the examiner inserts the catheter into the lumen of the common femoral artery just distal to the inguinal (Poupart's) ligament.

(b) An automatic injector is loaded with 60 cc of the contrast solution. The examiner gives the "Ready," signal and then rapidly injects the contrast solution. At the same time, the examiner (or an assistant) applies manual or mechanical pressure on the femoral artery proximal to the injection site.

(c) Additional exposures are made according to the examiner's instructions; for example, lateral or oblique. When it is undesirable to change the position of the patient, it may be necessary to use an extra machine, such as a mobile unit, for the lateral projections with the use of a horizontal CR.

(4) Radiographic exposure factors. The kVp is usually increased 10 percent over other exposures of the same part and the mA adjusted to hold density constant.

b. **Venography.**

(1) Preparation. Patient preparation and administration of sensitivity test have been covered earlier. Digital subtraction is used to demonstrate any part of the lower extremity.

(2) Preliminary procedure.

(a) As soon as the patient is received at the x-ray clinic, the specialist will ascertain from the examiner the area(s) of the extremity to be examined.

(b) For venography in the horizontal position, the patient is assisted onto the x-ray table and adjusted in the supine position. The lower extremity to be studied is aligned to the midline of the x-ray table if a Potter-Bucky diaphragm is to be used. For nongrid technique, the region of interest is adjusted over a suitable film-changing tunnel.

(c) For venography in the erect or the semi-erect position, the patient stands facing the x-ray tube on a footrest that has been fastened to the x-ray table. The x-ray table is tilted 65 to 80 degrees from the horizontal position. The footrest should be adjusted to a high enough elevation to permit the examiner to have reasonably easy access to the working site. An immobilization band should be placed over the patient's chest, just beneath the armpits, to provide support. The part to be examined is aligned to the image intensifier for digital capture. A 14 x 14-inch cassette is placed in the fluoroscopic machine.

(d) An infusion set for saline solution should be placed in a location that is safe and reasonably convenient to the part under examination.

(e) The site of injection is rendered aseptic and local anesthesia is administered.

(3) Injection of contrast medium and radiography.

(a) Injection may be made by the percutaneous method or by "cutting down" and surgically exposing a vein (which is rarely done anymore). The site of injection may be in either the retromalleolar region or the dorsum of the foot.

(b) A butterfly needle is primarily used, usually connected to a length of plastic tubing with an adapter attached. It is inserted in the vein and secured in position by adhesive tape.

(c) When indicated, venoclysis with normal saline solution is initiated. In some instances, venoclysis is done in both extremities.

(d) A rubber-like tourniquet is applied around the mid-calf or above the knee and tightened to impede the circulation in the superficial venous system.

(e) From 20 to 40 cc of a contrast solution is injected at rate varying from 1 to 5 cc per second.

(f) The examiner signals the specialist when the first exposure is to be made, anywhere from less than 5 seconds to more than 120 seconds following the injection. Venograms of the leg are shown in figure 3-9.

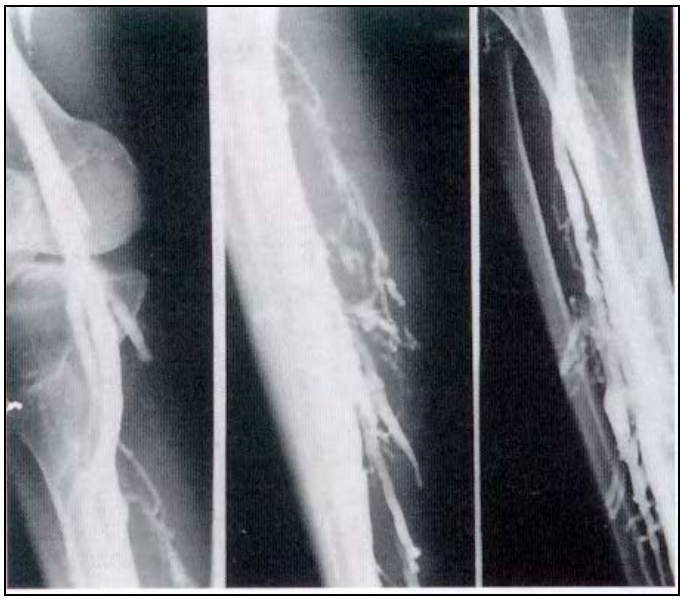


Figure 3-9. Venograms of the leg.

(4) Variations. There are numerous methods for venography of the lower extremities. Certain variations frequently resorted to are:

(a) Stereoradiography. Since the transport of the injected contrast material in the venous channels is relatively slow, stereoscopic projections are practical. Stereoscopy, however, requires the use of a suitable film-changing tunnel or the Bucky technique. The tube-shift should be made in a crosswise direction in relation to the long axis of the part under consideration.

(b) Projections. Because of superimposition of the tibia and fibula with certain venous channels, oblique projections (made with the leg rotated either internally or externally as directed by the examiner) or laterals may be especially indicated.

(c) Coverage. In certain cases, the first exposure is made to demonstrate the most distal portion of the extremity; subsequent exposures are made with each cassette positioned progressively nearer the regions, which lie proximally. Since the timing of these exposures and the order in which they are made is an extremely important factor, the specialist must carry out the instructions of the examiner with utmost exactness.

(d) Proximal injection method. The principal object of this method is to introduce the contrast medium into the proximal portion of the venous system of the lower extremity. The injection may be done in one of several ways. For example, the contrast solution is injected into either the median superficial or the lateral superficial vein of the penis in the case of the male patient or into the superficial circumflex iliac vein in the case of the female patient. The solution may also be introduced by direct-needle injection of the femoral vein in the region just below the crease in the groin or by

the insertion of a catheter into the saphenous vein in the region of the fossa ovalis after the vein has been surgically exposed. In practically every case, the patient is adjusted in the erect or the semi-erect position on the tilted x-ray table and facing the tube. The reason this position is used is to allow the injected contrast medium to gravitate into the dependent veins in retrograde fashion to the level of competent venous valves. Exposures of the pelvic and upper thigh regions are made immediately after the completion of the injection and, thereafter, as indicated by the examiner.

(5) Radiographic technique factors. The kVp is usually increased 10 percent over other exposures of the same part and the mA adjusted to hold density constant.

3-21. ANGIOCARDIOGRAPHY

a. **Patient Preparation and Administration of Sensitivity Test.** This is discussed earlier in this section (para 3-5).

b. **Preliminary Procedure.**

(1) An angiocardiographic layout and the necessary solutions are prepared.

(2) Pre-examination or control films are made and developed to establish the proper technique factors and to permit the examiner to select the most favorable position. These films are made as soon as the patient arrives at the x-ray clinic.

(3) The patient is positioned over a specially constructed device equipped with digital imaging capture systems (figure 3-7). Older systems have a roll-film (for example, Fairchild) magazine which is mounted on an adjustable and mobile stand.

(4) The site of injection is rendered aseptic and then local anesthesia is administered.

(5) A tourniquet is applied around the upper region of the patient's arm. Then, a suitable injection needle (for example, Robb-Steinberg, 12 to 15 gauge) is inserted into the antecubital vein, either percutaneously or after surgical exposure of the vein. Following this, the tourniquet is removed. In some instances, however, a special type of catheter is used for introducing the contrast medium. The catheter may be inserted into the external jugular vein and advanced through the femoral and iliac veins into the vena cava.

(6) In the absence of rapid-sequence, serializing-recording apparatus, it may be necessary to perform circulation-time tests to ascertain the relationship of the time interval between the commencement of the injection of the contrast medium and the occurrence of opacification of specific blood channels. A substance such as ether, sodium dehydrocholate (Decholin), sodium cyanide, fluorescein, or calcium gluconate is injected into the vein and specific reactions (such as bitter taste, odor of breath, yellowish coloration of the lips) manifested by the patient are noted and timed by a stopwatch. This provides a reliable means for predicting when maximum opacification of specific blood channels will occur and when the exposures should be made.

NOTE: If fluorescein is to be used, the specialist must take the necessary steps to darken the x-ray room and see that a Wood's lamp is on hand so that the fluorescent coloration of the patient's lips can be detected the moment it occurs.

(7) When indicated, the examiner, the patient, and the specialist (including any assistants) will rehearse the critical aspects of the injection procedure.

c. **Positioning the Patient.** The patient is usually placed in the horizontal position, either prone or supine (see figure 3-10). If he is obliqued and supporting material is used, the material must be free of any opaque substance. At the discretion of the examiner, the patient may be placed in the upright position.

Figure 3-10. Position of patient and examiner preparatory to injecting the contrast medium for angiocardiography.

d. **Projections.** The projections to be made for angiocardiography are determined by the examiner and will depend upon the nature of the given case. The specialist is concerned about the exact order and specific time the required films are to be exposed and, in the case of the obliques, also the degree of rotation to be used. As a rule, when rapid-sequencing recording apparatus in combination with a biplane exposure setup is used, simultaneous AP and lateral projections only are made.

e. **Injection of Contrast Medium and Radiography.**

(1) When everything is in complete readiness, participants alerted, x-ray unit turned on, technique factors selected, and the tube anode actuated to "exposure-rotation." the examiner draws about 10 to 15 cc of blood from the patient's vein into the syringe.

(2) The examiner instructs the patient to suspend respiration at the end of exhalation.

(3) Next, the patient is told to inspire rapidly and deeply and then to hold his breath.

(4) Simultaneously with the inspiration, 40 to 50 cc of the contrast solution is injected at a rate of about 25 to 35 cc per second. At the exact instant the injection is begun, the specialist starts the stopwatch.

(5) With his eyes on the stopwatch and his hand on the exposure controls, the specialist makes the first exposure at the predetermined instant.

(6) Additional exposures are made as ordered by the examiner.

f. **Radiographic Technique Factors.**

(1) The kVp is usually increased 10 percent over other exposures of the same par, and the mA adjusted to hold density constant.

(2) Special consideration should be given to the following:

(a) Exposure time. Due to the relatively rapid transport of the contrast medium in angiocardiography, the shortest practicable exposure time should be used. Exposure time for the average adult patient should not exceed 1/15 second. For a small child, it should not exceed 1/30 second. Under average conditions, exposure times of 1/30 second for the adult patient and 1/60 second for the small child patient are usually adequate. When allowed a choice, it may be preferable to use exposure times shorter than those given above.

(b) Kilovoltage, mAs. As compared to the kVp values for routine radiography of the chest of similar size and for comparable radiographs, an increase of about 15 percent is necessary for angiocardiograpy. When a grid is used, a tube tension of about 100 kVp is a sound starting value. The mAs values should be adjusted so as to obtain the desired density and contrast of the opacified structures, more or less disregarding the pneumatized lung fields. Whenever there is an element of doubt, it is better to favor overexposure than to risk underexposure.

(c) SID. An SID of 40 inches is generally used with interventional C-arms, but can be slightly greater with larger units.

3-22. CARDIAC CATHETERIZATION

a. **Patient Preparation and Administration of Sensitivity Test.** This has been covered earlier in the section. Figure 3-11 demonstrates a cardiac catheterization with the injection of contrast during diastole and systole.

b. **Preliminary Procedure.**

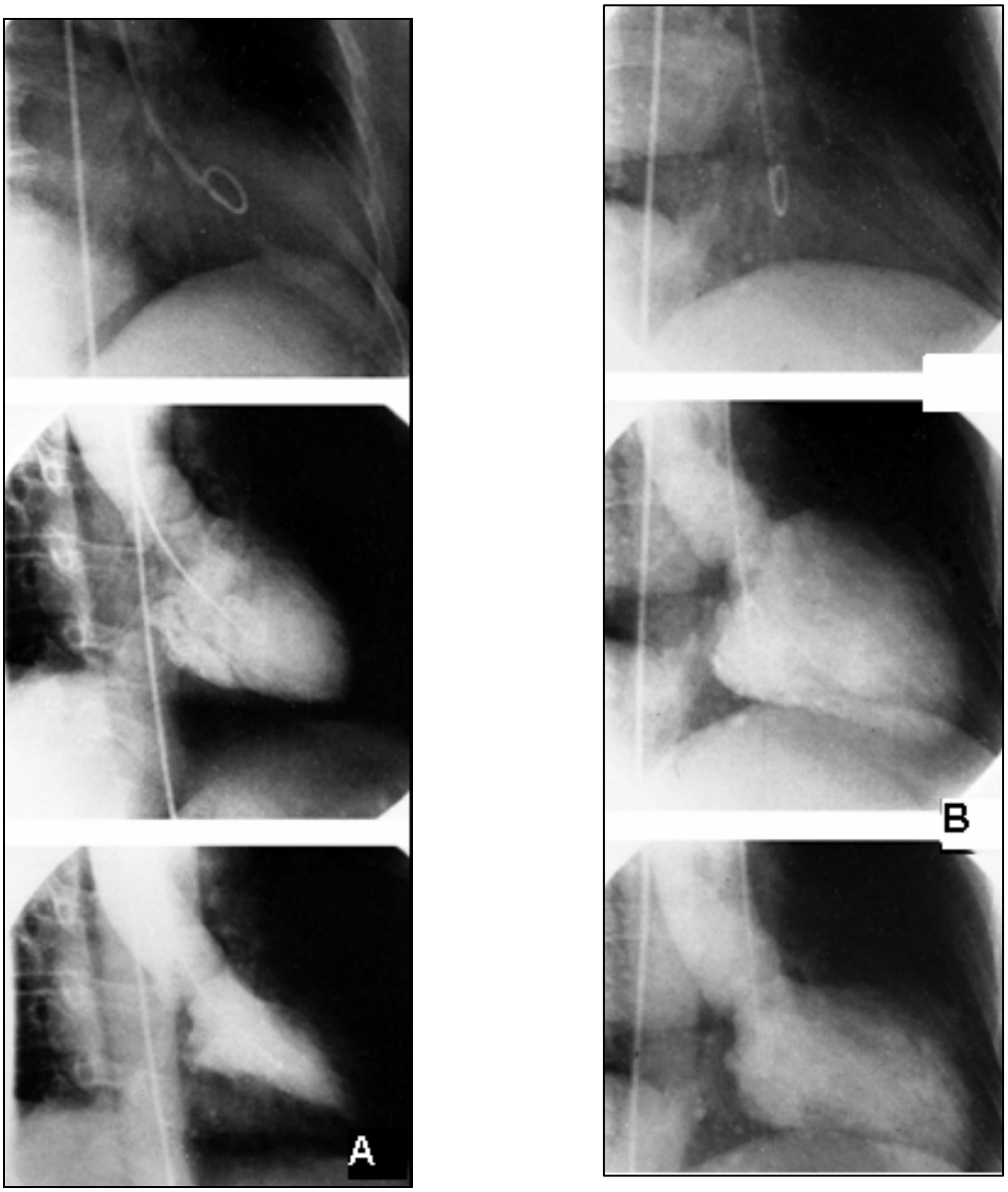
(1) A combination radiographic-fluoroscopic unit (and television, if available) is put in operative order by the specialist. The table unit is adjusted in the horizontal position and, when indicated, a soft synthetic rubber mattress is placed on the tabletop to ensure the comfort of the patient.

(2) When the patient arrives at the x-ray clinic, he is placed on the x-ray table in the supine position and sterile draped.

(3) A cardiac catheterization layout is prepared.

(4) The site of insertion (for example, antecubital fossa) is made aseptic, local anesthesia is administered, and a selected vein is surgically exposed. A size 8 or 9 French ureteral-type catheter, 100 to 125 cm long, connected to a regular saline infusion set by a stopcock complex and adjusted for continuous saline perfusion, is inserted into the vein through the surgically induced opening. The fluoroscopic apparatus and spot-film assembly are moved into position over the patient's chest, adjusted to the required height, and locked in place. The specialist should make certain that the self-recording time clock is in the catheter in the heart, fluoroscopic circuit and is set to accurately tally the total exposure.

c. **Fluoroscopic and Spot-Film Procedure.** The examiner advances the catheter into the initial position in the heart under fluoroscopic control. Samples of blood are aspirated into a syringe connected to the stopcock complex and transferred into special containers for laboratory analysis. Usually, spot films are exposed to record the catheter in the various positions. The spot films are numbered to correspond to the numbered samples of blood.



A. An example of midcavitary catheter position for left ventriculography using a pigtail catheter: before the injection of contrast (A-1), at end-diastole (A-2), and at end-systole (A-3).

B. Left ventricular inflow tract catheter position for right anterior oblique using a pigtail catheter: before the introduction of contrast (B-1), at end-diastole (B-2), and at end-systole (B-3).

Figure 3-11. Cardiac catheterization with the injection of contrast during diastole and systole.

d. **Selective Catheterization or Direct Angiocardiography.**

(1) Patient preparation has been covered earlier in this section.

(2) Procedure.

(a) Immediately after completion of cardiac catheterization, the patient is positioned for exposure of the angiocardiographic films.

(b) The stopcock complex is readjusted so that the contrast medium will flow from the previously filled syringe through the lumen of the catheter. Any equipment previously used for cardiac catheterization and not needed for this procedure will be disconnected and moved out of the way.

(c) Injection of the contrast medium and radiography are essentially the same as for intravenous angiocardiography with the execution of the exposure-timing phase being somewhat more critical. However, this difficulty is usually overcome by the use of an automatic injection device and a serial film changer.

3-23. ABDOMINAL ANGIOGRAPHY

a. **Aortography, Translumbar Percutaneous (Direct) Method.** See figure 3-12.

(1) Preparation. Patient preparation and administration of sensitivity test. This has been covered earlier in this section. Digital subtraction is used to demonstrate any part of the lower extremity.

(2) Preliminary procedure.

(a) A sterile layout consisting of the necessary instruments and materials is prepared.

(b) The X-Ray table is adjusted in the horizontal position.

(c) The patient is placed in the prone position on the x-ray table. An abdominal film (14x17-inch) is exposed and immediately developed. This film serves to check the adequacy of the pre-examination preparation of the patient's bowels, the most favorable centering of the film with respect to the area under examination, and the correctness of the technique factors.

(d) If the vascular structures in the pelvic region are to be studied, the examiner may request that sphygmomanometer cuff be adjusted around the proximal portion of both thighs and inflated to about 200 mm (millimeters) Hg (mercury).

Figure 3-12. Aortogram that shows opacification of aorta and tributaries.

(e) The patient is anesthetized by the intravenous administration of sodium pantothal.

(f) The area in and around the injection site is made aseptic and then sterile draped.

(g) The skin just below the 12th rib and approximately 7 cm to the left of the spinous processes is punctured with a relatively short thick needle. A special type of needle (15 cm in length and fitted with a stylet) is then passed through the puncture hole and directed toward a point just anterior to the body of the twelth thoracic vertebra. Upon approach of the needle point to the aortic wall, the stylet is removed and the needle is then cautiously advanced until characteristic physical manifestations indicate entry of the needle in the lumen of the aorta.

(h) The needle is then connected to the plastic tubing and syringe filled with sterile saline solution. The ease of flow throughout the injection route is checked by means of barbotage.

(i) The stopcock is then closed. The syringe is disconnected and filled with approximately 20 cc of the contrast solution. The syringe is reconnected and the stopcock complex adjusted. To make sure that the needle is well within the lumen of the aorta, the examiner may request an exploratory exposure the instant after injection of a relatively small amount of the contrast solution. This film must be processed immediately and presented to the examiner for reading.

(3) Injection of contrast medium and radiography.

(a) The examiner withdraws a few cubic centimeters of blood into the barrel of the syringe.

(b) When everything is in complete readiness, all participants alerted, x-ray unit energized, cassette in the Bucky tray, and technique factors set, the examiner gives the "Ready," signal to the specialist and starts the injection. At that instant, the examiner gives the signal "Now," or "Shoot," and the specialist makes the first exposure.

(c) The injection needle is removed by the examiner and the x-ray specialist (or an assistant) changes cassettes.

(d) Subsequent exposures are made at predetermined intervals. Exposures made from 2 to 4 seconds after completion of the injection will usually demonstrate the venous return.

(e) To obtain optimum radiographic quality in the aortogram, grid technique must be used. The exposure time should not exceed 1/10 second. Increase the kVp 10 percent above that which would be used for a similar projection without contrast medium, adjusting the mA to keep density constant. A pilot film should be made to check technique.

b. **Aortography--Retrograde Method.**

(1) Patient preparation and preliminary procedure. In general, the preparation of the patient and the preliminary procedure are the same as for the translumbar percutaneous method described above, with the following exceptions:

(a) The patient is adjusted in the supine position on the x-ray table.

(b) After aseptic preparation and local anesthesia, the femoral artery is the region of Scarpe's triangle located.

(2) Injection of contrast medium and radiography.

(a) Before starting the injection procedure, a final check is made of all apparatus for operative readiness.

(b) From 60 to 120 cc of the contrast solution is put into the auto-injector syringe.

(c) The syringe is connected to the injection system and the stopcock complex is adjusted.

(d) The examiner gives the "Ready," signal to the specialist and then starts the injection.

(e) When all but a few cubic centimeters of the contrast medium have been injected, the examiner will give the signal "Now," or "Shoot," and the specialist makes the first exposure.

(f) Subsequent exposures are made at predetermined intervals.

(g) The patient will control his respiration according to the instructions of the examiner.

c. **Venography of the Inferior Vena Cava (Cavagram).**

(1) Patient preparation and administration of sensitivity test. This has been covered earlier in this section (para 3-5).

(2) Preliminary procedure. Digital subtraction is used to demonstrate any inferior vena cava.

(a) The patient is placed in the supine position on the x-ray table.

(b) Pre-injection films (14x14-inch) are sometimes made to include an AP projection exposed with a vertical CR and a lateral projection exposed with a horizontal CR. Grid technique is used for both. These films are processed immediately and presented to the examiner for reading.

(c) While the projection films are being developed, the injection needle is inserted percutaneously into the lumen of the femoral vein. A plastic tube is then connected to the needle. Adhesive tape is used to hold the needle in place.

(d) In the absence of a simultaneous biplane exposure setup, the examiner will signify whether the AP or the lateral is to be exposed first.

(3) Injection of contrast medium and radiography.

(a) Approximately 120 cc of the contrast solution is put into the syringe. The syringe is then connected to the automatic injection system and the necessary adjustments of the stopcock complex are made.

(b) The examiner gives the "Ready," signal to the specialist and then starts the injection of the contrast solution at a rate of about 10 cc per second.

(c) The specialist makes the first exposure at the instant the examiner gives the signal.

(d) Subsequent exposures are made according to the instructions of the examiner.

d. **Portal Venography.**

(1) Methods. The methods of performing portal venography vary principally in the way the contrast medium is introduced.

(a) Operative method. The contrast medium is introduced through one of the tributaries (for example, right gastroepiploic, superior mesenteric) of the portal vein while exposed during abdominal laparotomy. This method is the only one that will be described here.

(b) Occlusal method. The vena cava is momentarily occluded at a specific level by means of a special type of balloon-catheter during the injection. The catheter is inserted via the femoral and iliac route into the vena cava.

(c) Percutaneous transhepatic method. The injection needle is inserted through the abdominal wall just below the xiphoid process of the sternum and then advanced through the liver into the portal vein.

(2) Patient preparation. The specific mode of patient preparation depends upon the method of injection and the demands of the clinical situation.

(3) Preliminary procedure.

(a) This examination should be done primarily in an interventional radiologic suite that has a digital subtraction capability. At the appointed time, the specialist will proceed to the designated operating room with a mobile x-ray unit and portable Bucky or gridfront cassettes. When the latter are to be used, a suitable cassette-changing tunnel may be required. The specialist must change into attire appropriate for operating room environment before he enters the sterile operating area. He must inquire of the surgeon in charge regarding the most favorable location for setting up the x-ray equipment.

(b) The patient is placed on the operating table in the supine position and draped for surgery. The specialist placed the portable Bucky grid or the cassette tunnel underneath the patient and centers the film in line with the siphoid process of the sternum and slightly to the right of the midline.

(c) A preliminary film (10 x 12-inch or 14 x 17-inch) is exposed and immediately process. This film is used to check the centering of the film and the correctness of the technique factors.

(d) Anesthesia is induced and the operating field is prepared for surgery.

(e) After surgical exposure, a plastic catheter is inserted into one of the tributaries of the portal vein, advanced into the portal, and then tied in place.

(4) Injection of contrast medium and radiography. See figure 3-13.

(a) An automatic injector syringe filled with 60 to 120 cc of a contrast solution is attached to the exposed end of the catheter. Meanwhile, the specialist will move the x-ray unit in place and center the tube over the area indicated by the surgeon. Before positioning the tube, the surgical site must be covered with a sterile towel or the tube assembly wrapped with a suitable sterile material.

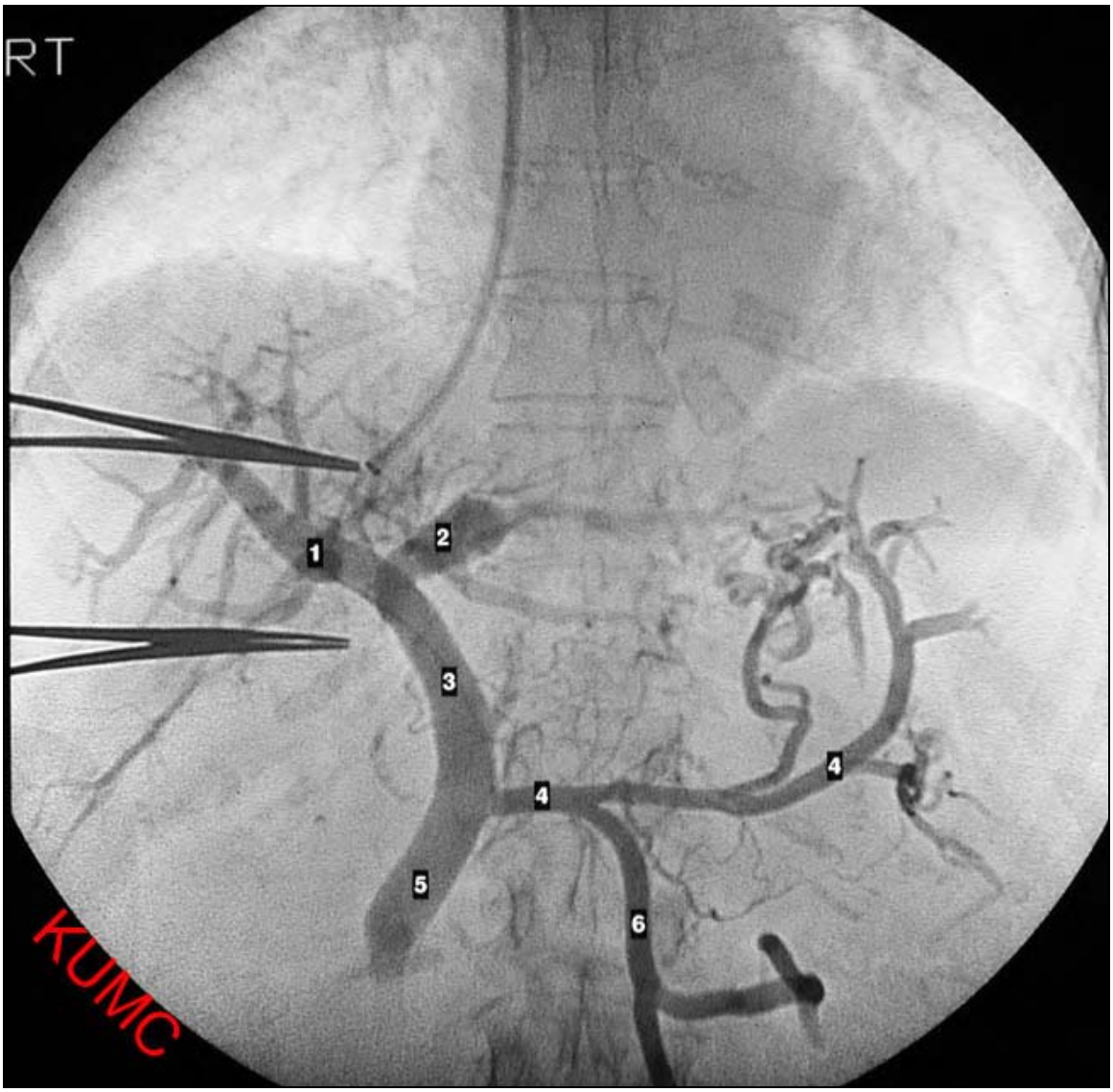
(b) With all participants alerted, the surgeon gives the "Ready," signal to the specialist and then starts injection of the contrast solution at a rate of 10 to 15 cc per second. Immediately upon completion of the injection, the first exposure is made. In some instances, the surgeon may instruct the anesthetist to induce apnea for the duration of the exposure in order to help overcome the possible loss of image detail caused by respiratory movement in the patient. This is especially advantageous in cases where a low-powered mobile x-ray unit is all that is available for use in the operating room. When apnea is induced, two factors are of prime importance.

1 The surgeon must determine the optimum time for the commencement of the injection concurrent with the inducement of apnea

2 The specialist must be prepared to make the exposure at the required instant.

(c) Subsequent exposures are made at predetermined intervals.

(5) Procedural variations. When the contrast medium is introduced by the transhepatic or the occlusal method, operating room facilities are not necessarily required. This is advantageous since it permits the use of automatic rapid-sequence serializing biplane exposure apparatus.



1. Right portal vein.
2. Left portal vein.
3. Main portal vein.
4. Splenic vein.
5. Superior mesenteric vein.
6. Inferior mesenteric vein.

Figure 3-13. Portal venogram showing the portal vein and tributaries injected with the contrast solution.

e. **Splenoportography (Percutaneous).**

(1) Patient preparation.

(a) General anesthesia may be administered either in the operating room or in the designated x-ray room. Only the latter situation will be described here.

(b) The patient is placed in the supine position on the x-ray table, and adjusted so that the sagittal plane located 1 1/2 to 2 inches medial to the midclavicular line is aligned to the midline of the x-ray table. A 10 x 12-inch or a 14 x 17-inch cassette is placed in the Bucky tray, positioned crosswise in relation to the midline of the patient, and centered to the level of the xiphoid process.

(c) A preliminary film is exposed and immediately processed. The film is used to check the adequacy of intra-abdominal preparation and the correctness of the technique factors.

(d) The anesthetist then induces general anesthesia and performs endotracheal intubation. In the meantime, the site of injection is made aseptic and sterile drapes are placed.

(e) The examiner inserts the injection needle in the midaxillary line (left side) in the 9th and 10th intercostal space. As the examiner advances the needle into the bulb of the spleen, he instructs the anesthetist to induce apnea.

(2) Injection of contrast medium and radiography (figure 3-13).

(a) A 50 cc syringe is filled with a contrast solution and then attached to the injection needle.

(b) With all participants of the medical team alerted and the x-ray apparatus adjusted and energized, the examiner again instructs the anesthetist to induce apnea and gives the "Ready," signal to the specialist.

(c) The examiner will now inject the contrast solution at a rate of 10 to 15 cc per second. Immediately upon completion of the injection, the injection needle is withdrawn and the first exposure is made.

(d) Subsequent exposures are made at predetermined intervals. In the event that rapid-serial radiography is used, the exposures are generally made at a continuous rate of one per second for 10 to 15 seconds.

3-24. CEREBRAL ARTERIOGRAPHY

a. **Patient Preparation.** This has already been discussed in this section (para 3-5).

b. **Preliminary Procedure.**

(1) The patient is placed in the supine position and centered to the midline of the x-ray table.

(2) Preliminary films of the skull (AP and lateral) are exposed according to the examiner's instructions. These films are processed immediately and presented to the examiner for reading.

(3) A sterile layout consisting of the instruments and materials required for cerebral arteriography is prepared.

(4) Radiation protection shielding should be arranged so as to provide the necessary safety and yet afford optimum freedom of movement for each member of the medical team.

(5) If the injection is to be carried out by the percutaneous method, the examiner palpates the femoral vein in the groin area to determine the best site for puncture.

(6) The examiner inserts the injection needle into the selected lumen of the vein and then engages the needle with the adapter in the injection system (figure 3-14).

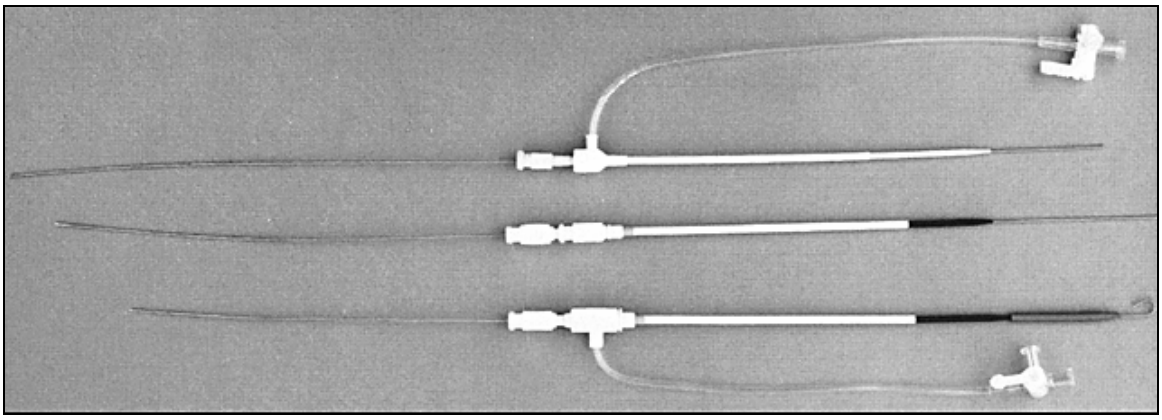
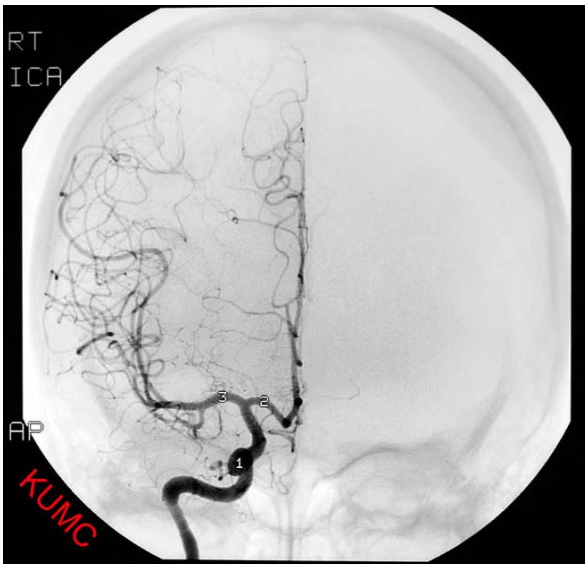


Figure 3-14. Showing relationships of the inserted injection needle, adapter, syringe, and stopcock complex for selectively directing the flow of contrast medium in the injection continuum.

c. **Injection of Contrast Medium and Radiography.** See figures 3-15 and 3-16.

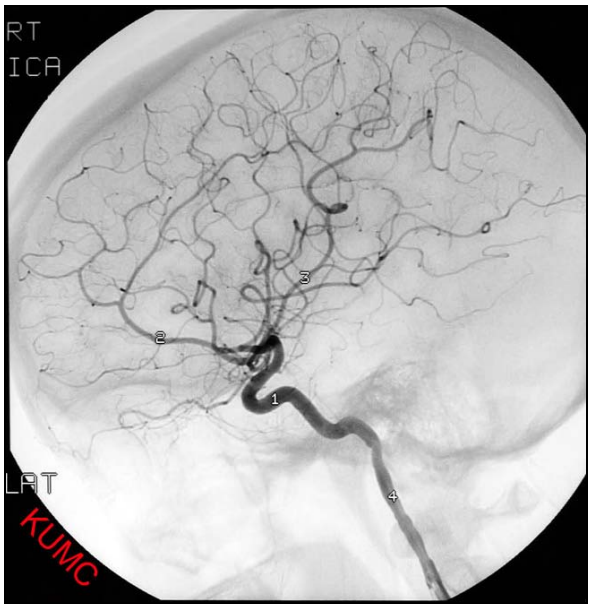
(1) The specialist adjusts the patient's head in the AP position. The CR is aligned parallel to the glabellomeatal line and directed to a point midway on line approximately 2 cm superior to the tragi.

(2) A syringe filled with approximately 20 cc of warmed contrast solution is attached to the stopcock complex.



1. Cavernous portion of internal carotid artery
2. Anterior cerebral artery
3. Middle cerebral artery

Figure 3-15. Cerebral arteriography, AP view.



1. Cavernous portion of internal carotid artery.
2. Anterior cerebral artery.
3. Middle cerebral artery.
4. Cervical portion of internal carotid artery.

Figure 3-16. Cerebral arteriography, lateral view.

(3) With all participants alerted and the x-ray unit in readiness for instant exposure (the rotating anode must be at exposure speed), the examiner gives the "Ready," signal to the specialist and injects the contrast solution at a rate of approximately 10 cc per second. Just as the final cubic centimeter leaves the syringe, the examiner gives the signal "Shoot," and the specialist makes the first exposure.

(4) In the absence of rapid-sequence serializing exposure apparatus, the specialist (or an assistant) will rapidly exchange cassettes and then expose the second film as quickly as possible. The pressure on the opposite side of the injection site is now released. The second exposure, when executed 3 to 5 seconds after injection, will represent the radiopaque medium passing through the venous phase of circulation. This film is actually a type of cerebral venogram.

(5) The manner in which the next step of the procedure is carried out depends largely upon the decision of the examiner. For example, he may order that fronto-occipital and/or lateral projections be made addition to the AP.

(6) Exposure time should not exceed 1/4 second. The timing of the exposures in relation to the time of injection is a vitally important point.

(7) All exposed films should be processed immediately and placed in an illuminator for viewing by the examiner before the patient is removed from the table.

d. **Variations.** When direct percutaneous injection of the contrast substance is made into the vertebral artery, the procedure is called vertebral arteriography. With certain exceptions, the procedure is similar to that for cerebral arteriography by carotid injection (supine position). In this case, the patient does not lie directly on the table surface. Instead, a firm cushion (approximately 6 inches high) is placed beneath the thoracic and pelvic regions and the head is hyperextended so that vertex of the skull rests on the table surface. Submentovertical projections are exposed during the first injection and such other projections as the examiner may direct during subsequent injections.

e. **Cerebral Arteriography by Use of Special Equipment.** Special equipment is used in various installations throughout the Army, such as automatic biplane C-arm image intensifiers, with a digital subtraction capability used to demonstrate any part of the cerebral anatomy. Notwithstanding the complexity of this type of apparatus, the procedural principles are basically the same as when conventional equipment is used.

3-25. CEREBRAL VENOGRAPHY AND SINUS VENOGRAPHY

a. **General.** Cerebral venograms may be produced incidental to cerebral arteriography when exposures are made during the venous phase of circulation. Certain diagnostic situations, however, demand a more detailed demonstration of specific venous channels than is afforded by this type of venogram (which is actually the result of indirect venography); for example, when it is desirable to obtain a more selective filling of specific venous channels with accompanying lack of dilution of the contrast substance. The preparation of the patient, preliminary procedure, positioning technique, and radiography are, for the most part, the same as for cerebral arteriography. The principal difference lies in the methods of introducing contrast medium.

b. **Injection Method for Superior Sagittal Sinus Venogram.** With the patient in the supine position on the table, the examiner makes an incision at the hairline in the mid-forehead area after having induced local anesthesia. A burr hole is made, then a ureteral-type catheter is inserted. The exposed end of the inserted catheter is connected to the stopcock complex and the usual infusion apparatus. Approximately 15 cc of the contrast solution (sterile aqueous type containing 35 percent iodine compound) is injected at a rate of approximately 5 cc per second. The first exposure is made at the completion of injection. Subsequent injections and views are made in accordance with clinical dictates.

c. **Injection Method for Retrograde Jugular Venogram.** The patient is placed in the supine position on the x-ray table. After aseptic preparation and administration of local anesthesia, an antecubital vein is surgically exposed. A cardiac catheter is inserted into the selected vein and then advanced to the desired level in the jugular vein under fluoroscopic control. The patient's head is positioned for the lateral view. Approximately 25 cc of contrast medium is injected through the catheter at a rate of 10 to 15 cc per second. The first exposure is made just as the last of the contrast medium leaves the syringe. In some instances, the examiner may have an assistant exert manual pressure on both jugular veins during injection. Subsequent injections and/or exposure are made in accordance with clinical dictates.

3-26. INTRA-OSSEOUS VENOGRAPHY

In this method of venography, the contrast medium is introduced into selected venous pathways via the intramedullary or intraspongious route. In some situations, this technique may offer certain advantages over those previously described. The specialist should consult standard textbooks on this subject.

3-27. LYMPHANGIOGRAPHY

a. This is a radiographic procedure, which will allow visualization of the lymph nodes and lymphatic channels by the use of contrast media. The lymph vessels and nodes of the extremities as well as the retroperitoneal areas can be visualized by this technique.

b. The examiner injects 6 cc Ethiodol (ethyl ester of iodized poppyseed oil containing 37 percent iodine) in the upper extremity or 12 cc into the lymphatic vessels of the lower extremities. For infants and children, the total amount injected is one-third to two-thirds that for adults. At the completion of the injection, the exposures are made. For lymphangiograms of the lower extremities, AP projections are taken of the legs, thighs, pelvis, abdomen, and chest. For the upper extremities, AP projections include the forearm, arm, shoulder, and chest.

Section III. THE CENTRAL NERVOUS SYSTEM

3-28. INTRODUCTION

The central nervous system consists of the brain and spinal cord. Because there is insufficient difference in densities of the tissues to allow for satisfactory visualization of the various structures of the central nervous system by conventional radiography, specialized radiographic techniques must be used. The attending physician and the radiologist determine the specific method.

3-29. VENTRICULOGRAPHY

Ventriculography is a diagnostic procedure whereby several radiographs are made of the head in various positions following the removal of all or a certain portion of the cerebrospinal fluid and its replacement with a suitable contrast medium. The ventricles are reached with hollow needles through small trephine openings in the skull.

a. **Patient Preparation and Scheduling.** Except in emergency, the examination is scheduled. Usually, the patient is sedated the evening before and again on the morning of the examination according to the directions of the responsible clinician. Breakfast is withheld on the morning of the examination.

b. **Preliminary Procedure.**

(1) The patient is taken to the designated operating room, where he is placed in a sitting position with his chin resting on a suitable support. After aseptic preparation and administration of local anesthetic, two small openings are made with a trephine in the skull, 6.5 cm to 7 cm above the occipital protuberance, and 3 cm lateral to the midline. A needle or cannula is introduced into each of the trephine openings, and then advanced into the ventricular cavities. A mercury manometer is used to

measure the intracranial pressure. Approximately 1 cc of indigo carmine is injected into one of the ventricles and allowed to diffuse for a period of several minutes. The cerebrospinal fluid is allowed to drain slowly from the two ventricles and is carefully collected in a graduate for measuring. To promote drainage, the patient's head is positioned so that the exposed portions of the cannulas are dependent. The patient's head is then positioned so that one cannula is lower than the other to permit the cerebrospinal fluid to drain from the lower cannula while air (the contrast medium) flows into the ventricular system through the upper cannula. This procedure is continued until approximately 25 to 30 cc of the cerebrospinal fluid has been withdrawn and replaced with air.

(2) This phase of the examination may vary. For example, drainage of the cerebrospinal fluid may be accomplished by means of a syringe (Luer type) attached to the cannula with flexible tubing. In this method, small quantities of cerebrospinal fluid are withdrawn (5 to 10 cc at a time) and replaced with carbon dioxide (CO_2). This procedure is continued until gas instead of fluid is returned upon aspiration.

(3) When the injection of the contrast medium has been completed, the cannulas are removed, the scalp is sutured, and a dressing is applied. Immediately following this, the patient is brought to the x-ray room for the ventriculographic examination.

c. **Radiographic Procedure.**

(1) Basic routine. Ordinarily, AP, PA, and right and left lateral projections of the skull are first made with the patient in a horizontal position. Then a similar set is made with the patient in an upright (sitting) position. The exposure factors are usually the same as those used for routine skull examinations.

(2) Central ray-part relationships. For the sagittal (axial) projections (that is, AP and PA), the vertically or horizontally projected CR is directed along the IOML (infraorbitomeatal line) and in line with the midsagittal plane of the skull. The laterals are made similarly to routine laterals of the skull.

(3) Additional positions and projections. Additional projections may be taken in various positions with various CR relationships to include any one or several as shown in Table 3-2.

View	Patient-part position	Projection
Right and/or Left lateral.	Supine decubitus, brow-up; film-plane vertical.	Horizontal.
Right and/or Left lateral.	Prone decubitus, brow-down; film-plane vertical.	Horizontal.
Right and/or Left lateral.	Supine decubitus, head inclined backward and downward (with hyperextension of neck) and extending over and below the end of the table, so that Reid's Base Line (RBL) assumes a horizontal relationship. Film-plane vertical.	Horizontal.
Right and/or Left lateral.	Prone decubitus, head inclined forward and downward (with flexion of the neck) extending over and below the end of the table with the coronal plane of the head approximately 5º to 10º from the vertical relationship. Film-plane vertical.	Horizontal.
Right and/or Left lateral.	Horizontal (prone or supine), head extending beyond end of table (or litter) and held in place beneath horizontal film-plane by a suitable supportive device.	Vertical CR projected from below.

Table 3-2. Additional projections of ventricles (continued).

View	Patient-part position	Projection
Anterior-Posterior.	Right and left lateral decubitus; film-plane vertical.	Horizontal.
Anterior-Posterior.	Prone decubitus, head extending beyond end of table (or litter) and held in place beneath horizontal film by a suitable supportive device.	Vertical CR projected from below.
Posterior-Anterior.	Right and left lateral decubitus; film-plane vertical.	Horizontal.
Posterior-Anterior.	Supine decubitus, head extending beyond end of table (or litter) and held in place beneath horizontal film by a suitable supportive device.	Vertical CR projected from below.
Occipital-Frontal.	Upright (sitting position), facing Vertical film, head inclined forward, neck and body flexed coronal plane of head approximately 45º to 50º from the vertical relationship (Waggoner-Clark position).	Horizontal CR directed midsagittally approximately 1º above level of external auditory meati.

Table 3-2. Additional projections of ventricles (concluded).

(4) Stereoradiography. Stereoscopic exposures are frequently made. These are exposed in pairs and usually include both laterals and one or both sagittal projections. It is extremely important that the specialist know in advance the exact positions in which the stereo pairs are to be made. Normally, the tube is shifted longitudinally for the sagittal projections and transversely for the lateral projections.

(5) Grid technique. When possible, grid technique should be used for all ventriculographic exposures. If a special head unit is not available, it may be necessary to use grid-front cassettes or a wafer-type grid for the right angle projections. Customarily, two right-angle projections are made for each head position used. Ideally, each pair should be made without changing the position of the patient's head since even a slight deviation in position may change the distribution of the cerebrospinal fluid and the contrast medium within the ventricular system, resulting in dissimilarity of object-representation between the sagittal and lateral projections.

(6) Precautions. To obtain the best results, the patient must be properly immobilized and must suspend respiration during exposure of the films. The positioning of the head and the centering of the CR must be done with extreme care and exactness. The mAs selected should be such as to allow use of the shortest possible exposure time. Arrangements must be made for the films to be processed immediately and presented to the radiologist for reading before the patient leaves the x-ray department. The entire procedure must be under aseptic conditions.

d. **Variations of Technique.**

(1) Ventriculo-encephalography. This technique is used to demonstrate structures in the posterior fossa that cannot be shown clearly by regular ventriculography. A certain amount of cerebrospinal fluid is withdrawn by spinal puncture (spinal tap) and replaced with air or other suitable gas. As soon as the required amount of fluid has been drained off and replaced with air, the various exposures are made at the direction of the examiner.

(2) Radiopaque contrast ventriculography. In this method, a radiopaque contrast medium is introduced into selected portions of the ventricular system of the brain and a series of radiographs made utilizing several positions. If indicted, this procedure is usually performed immediately following gas ventriculography.

(a) The patient is seated in the erect position in front of a vertical fluoroscopic table unit for lateral viewing of the skull by the examiner.

(b) The patient's neck and body are flexed so that the foramen magnum is at higher level than the vertex of the skull. The head is then rotated so that one of the trephine openings is uppermost.

(c) Using a syringe with needle attached, the examiner introduces approximately 2 cc of contrast medium (for example, Pantopaque) into the lateral ventricle via the upper trephine opening.

(d) The examiner signals the specialist to engage the fluoroscopic unit and then proceeds to maneuver the contrast agent into the third ventricle by postural manipulation of the patient's head, neck, and body.

(e) When the contrast agent is in the third ventricle, the examiner will signal the specialist to prepare for the required radiography.

(f) Usually, the prescribed sagittal and lateral projections are made without changing the position of the patient's head or body. Additional projections may be made in various other positions according to the directions of the examiner.

(g) Arrangements should be made for the films to be developed and presented to the radiologist for reading immediately upon completion of the exposures.

(h) If additional films are not required, the examiner will posturally manipulate the patient (with the help of the specialist or an assistant) in such a way as to cause the contrast medium to collect in the dural sac for subsequent removal by spinal puncture.

3-30. MYELOGRAPHY

a. **General.**

(1) Myelography is a procedure for the investigation of the spinal cord and subarachnoid spaces following the introduction of contrast medium into the spinal canal.

(2) Pantopaque (ethyl iodophyenylunde-cylenate), an oily iodinated organic compound, is the preferred contrast media; however, in some localities or in special situations, substances in the sterile aqueous category (for example, Hypaque) may be used. The following concerns techniques in which Pantopaque is used. When air or oxygen is used for the contrast medium, the procedure is termed pneumomyelography.

(3) Since the majority of myelographic studies are concerned with the lumbar region of the spine, emphasis is placed on the techniques used in studies dealing with that region (commonly termed lumbar myelography). Not infrequently, however, it is the thoracic or the cervical region that is the site of prime diagnostic interest. For pertinent technical details relating to thoracic myelography and cervical myelography, see g and h below; otherwise, the essential technical details are the same as those described for lumbar myelography.

b. **Patient Preparation and Scheduling.** Except in emergencies, myelographic examinations are scheduled according to the established clinical procedure. Sedation is administered by the responsible clinician approximately one hour prior to the procedure.

c. **Preliminary Procedure.**

(1) Upon arriving at the x-ray department, the patient is properly gowned for the examination and the pertinent aspects of the procedure are explained to him.

(2) The patient is placed on the horizontally adjusted radiographic-fluoroscopic tilt-table unit, either prone or on his side depending upon the preference of the examiner. If preliminary radiography is not required, the positioning procedure is as follows:

(a) Patient prone (figure 3-17). The patient is adjusted in the prone position with the midline of the body aligned to the center of the table; the head may be turned to either side. The patient is then instructed to grasp the edge of the tabletop with his hands at the level of his shoulders or to grasp the shoulder brace with one hand. To straighten the lumbar curve to the required degree, a bolster (made by rolling a small pillow or other suitable object into the desired shape) is placed under the lower abdomen. The patient's feet are placed firmly against the footrest.

Figure 3-17. Head-end of tilt-table unit raised during myelographic examination.

(b) Patient lying on his side (figure 3-18). The patient lies on his side, with his back toward the examiner. A suitable bolster is placed under the thoracic region to straighten the spinal column in relation to the midsagittal plane and make it parallel with the tabletop. The patient's neck, body, and lower extremities are then brought into flexion so that the knees are drawn toward the chin and arms and shoulders are drawn forward.

(3) A sterile-packed myelographic layout is set up near the examiner.

(4) The injection site is made aseptic and local anesthesia is administered.

(5) The radiographic and fluoroscopic factors are determined according to the size of the patient. If necessary, test exposures are made and developed for immediate inspection. The specialist should prepare the radiographic room for the examination so that every item needed will be in place. A sufficient number of films of the required sizes should be available both for spot-filming and for other radiography. Appropriate identification markers should be made before any radiography is done.

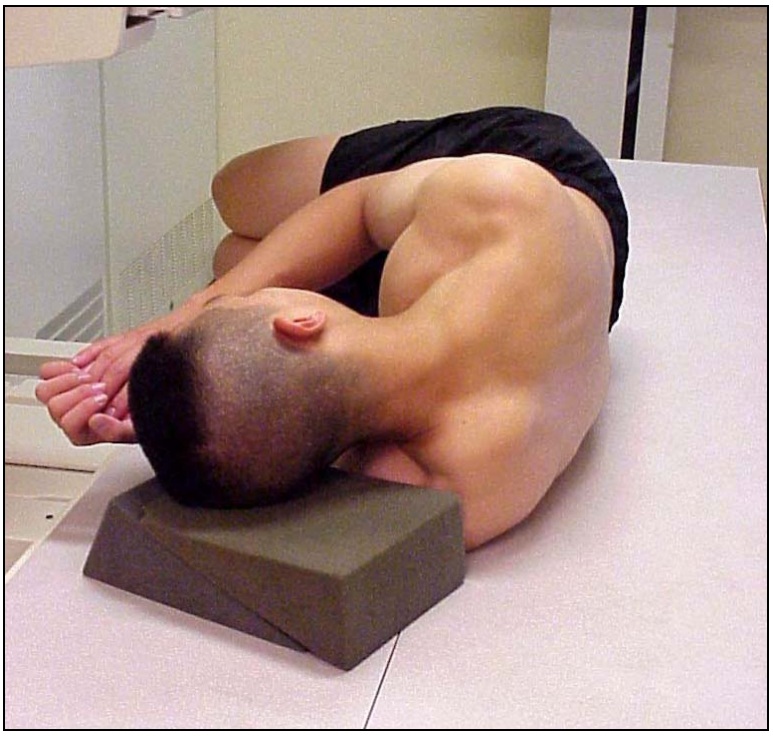


Figure 3-18. Patient lying on his side, body in flexion, for myelography.

d. **Introduction of Contrast Medium, Fluoroscopy, and Radiography.**

(1) Sterile and aseptic precautions are observed throughout the entire procedure.

(2) The examiner inserts an 18- or 20-gauge lumbar-puncture (short-beveled) needle into the subarachnoid space exactly in the midline and in the region of the vertebral interspaces between L3 and L4, L4 and L5, or L5 and S1. The stylet is removed from the needle and approximately 3 to 5 cc of cerebrospinal fluid are withdrawn and collected in a test tube for laboratory analysis. When indicated by the examiner, the Queckenstedt test is performed for the determination of possible block in the vertebral canal. In the absence of an assistant, the examiner may direct the specialist to assist him in this maneuver (carotid artery compression). In this case, the specialist must carry out the examiner's instructions (however simple they may seem) with exacting care. The cerebrospinal fluid pressure is recorded at this stage of the procedure.

(3) The head-end of the table is now raised approximately 10 to 20 degrees from the horizontal (figure 3-18). If the patient is lying on his side, he must be adjusted in the prone position. The injection site is covered with sterile gauze or a towel. The fluoroscopic apparatus and spot-film device are then brought into operative position over the injection site. Proper precautions must be taken to avoid disturbing the position of the needle. The specialist should be sure that the fluoroscopic apparatus is locked and the locking mechanism is absolutely safe. In some instances, a safety-bar may be used as an additional safeguard. The safety-bar may be contrived of an ordinary piece of wood or metal that is sturdy enough to serve the purpose. It is advisable to have safety-bars made up in several lengths to accommodate patients of varying sizes. If necessary, the safety-bar can be tied, taped, or clamped onto the upright support assembly that maintains the fluoroscopic apparatus and spot-film device.

(4) Fluoroscopy and spot-film radiography are then carried out. In some instances, however, the examiner may forego the latter aspect of the examination and proceed to inject the contrast medium instead.

(5) A syringe filled with the contrast medium (3 to 4 cc) is attached to the needle. The subsequent steps of the procedure depend upon the amount of contrast medium (with specific reference to Pantopaque) used.

e. **Technique in Which a Relatively Small Amount (2 to 6 cc) of Contrast Medium is Used.**

(1) After the introduction of the contrast medium into the subarachnoid space, the syringe is disengaged from the needle, the stylet is replaced, and the injection site is covered with sterile gauze or a towel. The bolster is removed from beneath the abdomen and placed under the patient's lower extremities, as needed.

(2) The fluoroscopic apparatus and spot-film device are brought into working position over the injection site. The apparent shape, location, and behavior of the body of injected contrast medium is studied by the examiner under fluoroscopic control as the table unit is raised or lowered according to his instructions. The position of the patient in relation to the tabletop may be changed at intervals. For example, the patient may be obliqued either to the right or the left, or postured on his side. In handling the patient, great care must be taken to see that the needle does not hit the fluoroscopic apparatus.

(3) Spot-film exposures are made at various intervals and in different positions. The patient should be instructed beforehand that he is to immediately suspend respiration at a given signal from the examiner or the specialist. In addition to the spot-films, PA (figure 3-19) and lateral projections (figure 3-20) may be made without changing the position of the patient. For the lateral projection, a horizontal CR is preferable. Spot obliques and/or stereoscopic exposures are made as indicated by the examiner.

Figure 3-19. Patient positioned on tilt-table unit, head lowered, for pneumomyelography.

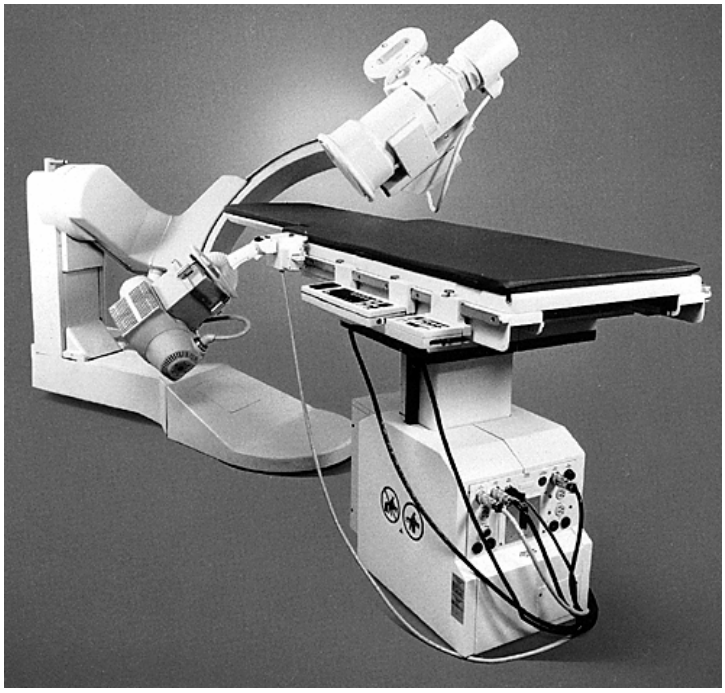


Figure 3-20. Equipment used in an interventional radiography suite.

(4) Radiopaque markers may be taped to the patient's body (or to the grid) to indicate anatomical relationships or landmarks. In any case, at least one of the radiographs out of each group (exposed at right angles to each other) should provide sufficient coverage to facilitate positive identification of the pertinent relationships between the position of the lumbar-puncture needle, the contrast medium situated in the spinal canal, and the important anatomical landmarks.

f. **Technique in Which a Relatively Large Amount (6 to 21 cc) of Contrast Medium is Used.** This is sometimes referred to as "full-column myelography," erect-method myelography," or "total myelography."

(1) Upon completion of the preliminary phases of the procedure, the patient is adjusted in a lateral recumbent position on the tilt-table unit. The spinal-puncture needle is inserted, a cerebrospinal pressure reading is recorded, and cerebrospinal fluid is collected for laboratory analysis.

(2) The head-end of the table is now raised approximately 10 to 20 degrees from the horizontal. The contrast medium is injected into the subarachnoid space in the lumbar region after withdrawal of a similar amount of cerebrospinal fluid. The lumbar-puncture needle is then removed and the patient is adjusted in the same position with his feet placed firmly against the footrest.

(3) After properly alerting the patient, the table is brought into the vertical relationship. Additional fluoroscopy, spot-filming, or radiography is carried out according to the directions of the examiner. The table is then returned to the horizontal relationship and the patient lies in the supine position. Further fluoroscopic and radiographic studies may be carried out, if indicated.

(4) Upon completion of the examination, the spinal-puncture needle is reinserted for subsequent removal of the contrast medium.

g. **Thoracic Myelography.**

(1) Patient prone. The patient is placed in the prone position on the tilt-table unit with the head fully extended. Some examiners may prefer to elevate the lower back by placing a suitable bolster under the lower abdominal region. The contrast medium and the manner of its introduction are essentially the same as in lumbar myelograph. In some instances, however, the contrast medium may have to be injected. Under fluoroscopic control and by slowly lowering the head-end of the table, the column of radiopaque control medium is made to flow into the subarachnoid space of the thoracic spine. Spot-films are taken in various positions as indicated. Conventional radiographic technique may be used for the sagittal and lateral projections. With the lateral projection, a horizontal CR is preferred.

(2) Patient supine. This technique may be used when a relatively large amount of contrast medium is injected. After completion of the injection, the needle is withdrawn and the patient is placed in the supine position on the tilt-table unit. The table is tilted and desired. The flow of the contrast medium is observed fluoroscopically and spot-films are taken in various positions as indicated.

(3) Removal of contrast medium. When the examination has been completed, the head-end of the table is raised so that the patient is brought to the vertical (or near-vertical) position, thereby pooling the contrast medium in the lumbar subarachnoid space for subsequent removal.

(4) Incidental blockage. In the event of incidental blockage of the spinal canal due to pathologic condition in the thoracolumbar region, it may be necessary for the examiner to inject the medium by means of cisternal puncture. In this case, the tilting procedure is the reverse of that used for the lumbar-puncture method.

h. **Cervical Myelography.** The patient is placed in the prone position on the tilt-table unit, with the head fully extended. The head must be fully extended to prevent the contrast medium from entering the cranial cavity. Contrast medium is introduced into the lumbar subarachnoid space in a manner similar to that in lumbar myelography. By lowering the head-end of the table, the examiner maneuvers the column of contrast medium from the lumbar region toward the cervical subarachnoid space. This is done under fluoroscopic control. Spot-film exposures are made for the sagittal projections. Lateral projections of the cervical region are obtained with the radiographic tube and a horizontal CR. After completion of the examination, the contrast medium is pooled under the lumbar-puncture needle for subsequent removal.

i. **Removal of Contrast Medium from the Subarachnoid Space of the Spine.** Removal of contrast medium is done only under fluoroscopic control. Two methods are described below.

(1) In one method, the patient is placed in the prone position on the tilt-table unit. By appropriate tilting of the table and under fluoroscopic control, the column of contrast medium is pooled under the spinal-puncture needle. An unused sterile syringe is then attached to the needle and the contrast medium is carefully aspirated. In case the needle was withdrawn immediately after the introduction of the contrast medium, a second spinal puncture is performed over the area and the contrast medium is removed as described above. Before the needle is withdrawn, a radiograph, or a fluoroscopic examination should be made to determine if satisfactory removal has been accomplished. If satisfactory removal is confirmed, the needle is withdrawn and the patient is returned to the ward.

(2) In the second method, the procedure is the same as outlined above until the contrast medium is pooled under the needle, but differs thereafter. When the contrast medium has been pooled under the needle, the stylet is removed but, in this case, no syringe is attached. Instead, the patient is instructed to do the Valsalva maneuver in which he takes in a deep breath and carries out forced expiration against a closed glottis. This aids in causing the contrast medium to flow out through the needle. The maneuver is repeated until all (or most) of the contrast medium has been removed. Before the needle is withdrawn, a radiograph, or a fluoroscopic examination should be made to see if satisfactory removal has been accomplished. If satisfactory removal is confirmed, the needle is withdrawn and the patient is returned to the ward.

3-31. DISKOGRAPHY

Diskography is the radiographic investigation of selected intervertebral fibrocartilages (disks) during radiopacification by a contrast medium. Examinations of this type are normally done in the operating room or interventional radiology suite using a C-arm. See figure 3-20.

a. **Preparation of Patient Scheduling.** The examination is scheduled according to the established clinical procedure. Sedation is usually administered one hour prior to the procedure.

b. **Preliminary Procedure (Lumbar Diskography).**

(1) When indicated, pre-injection radiographs are made of the area(s) of diagnostic interest.

(2) For lumbar diskography, the patient is usually placed on his side (laterally recumbent) on a tilt-table unit with his body in flexion (as for routine spinal anesthesia). In some instances, the examiner may prefer to have the patient placed in the prone position.

(3) The lumbar area is made aseptic and local anesthetic is administered.

(4) Under sterile precautions, the examiner inserts a No. 19 needle (1 1/2 inches long) in the midline aiming at the center portion of the intervertebral disk to be punctured. A lateral projection is then obtained to check the exact location and alignment of the needle.

(5) When it has been established that the No. 19 needle is properly aligned, a smaller caliber needle (No. 22, 4 inches long) is inserted into the No. 19 needle. The smaller needle is then advanced into the lumbar subarachnoid space. At this point, cerebrospinal fluid may be withdrawn and collected for laboratory examination.

(6) Next, the smaller caliber needle (No. 22) is advanced until its tip enters the nucleus pulposes of the intervertebral disk under consideration. In some cases, a lateral projection is made to check the precise position of the needle. If necessary, additional pairs of needles may be inserted in one or more of the adjacent intervertebral spaces.

c. **Introduction of Contrast Medium and Radiography.**

(1) A syringe (for example, Luer-Lok, 10 cc) filled with approximately 5 cc of the contrast medium consisting of one of the sterile aqueous solutions (for example, Hypaque) and containing from 35 to 50 percent iodine compound is then attached to the smaller caliber needle.

(2) After the specialist has readied the radiographic apparatus and placed a cassette in the Bucky tray, the examiner injects the contrast medium into the intervertebral disk. In the case of a normal disk, approximately 0.5 to 1 cc of the contrast solution may be injected. If abnormal conditions are encountered, more contrast solution may be injected--usually from 2 to 5 cc (or more).

(3) PA and lateral projections (figure 3-21) of the injected disks are obtained as soon as possible following the injection. These radiographs are made without changing the position of the patient. This technique usually requires a portable Potter-Bucky diaphragm or grid-front cassettes for the horizontal CR.

(4) The examiner now removes the needles and an appropriate dressing is applied to the puncture site. The patient is then placed in the supine position and the spinal column is flattened by flexion of the knees. AP projections (figure 3-22) are obtained. Stereoscopic exposures are made according to the instructions of the examiner.

(5) The table is then brought to the vertebral relationship, and lateral projections are obtained with the patient in the standing (weight-bearing) position.

(6) All exposed films should be developed and presented to the examiner for inspection before the patient is returned to the ward.

(7) If additional projections (for example, oblique) are required, they must be exposed as quickly as possible; otherwise, absorption of contrast medium may diminish radiopacification to such a degree that satisfactory radiographs cannot be obtained.

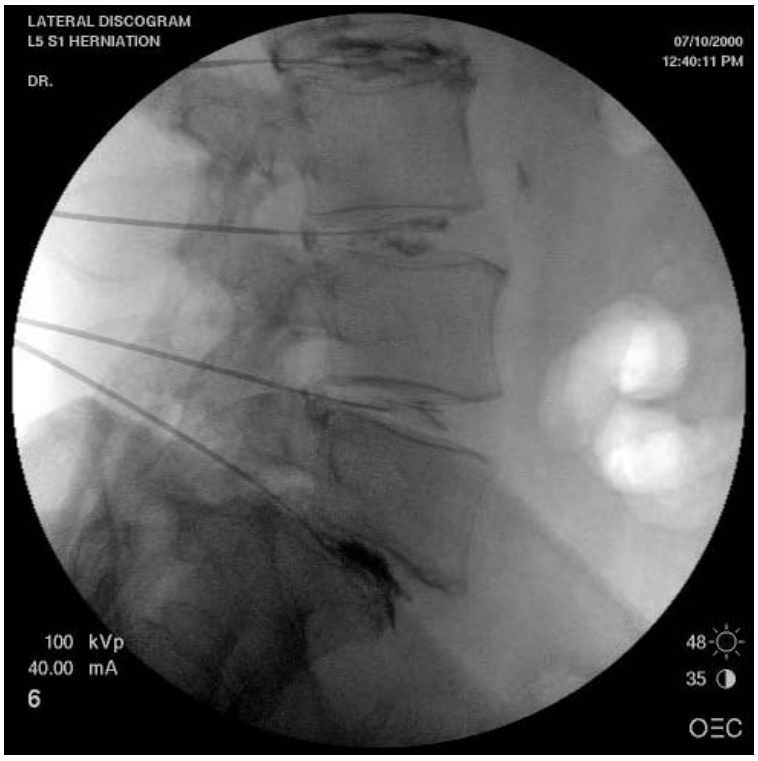


Figure 3-21. Diskography -lateral view. Needle localization with contrast injection.

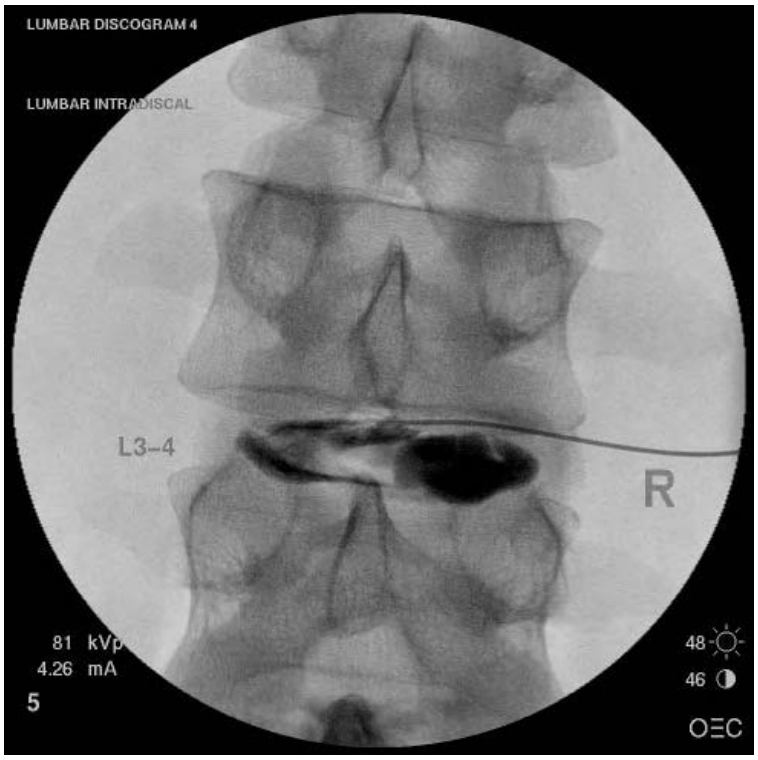


Figure 3-22. Diskogram sagittal view.

d. **Cervical Diskography.** For cervical diskography, the technical procedure closely follows that described for lumbar diskography with the following exceptions:

(1) The patient is placed in the supine position on the tilt-table unit. Pre-injection radiography is carried out according to the demands of the situation.

(2) The antero-lateral aspect of the patient's neck on the side of interest (or the most suitable site of access) is made aseptic and local anesthetic is administered.

(3) The examiner inserts the injection needle(s) into the tissues lying in the antero-lateral aspect of the cervical region and directs it toward the intervertebral disk(s) under consideration. A single 21-gauge, 9-cm spinal needle, or a pair of needles, consisting of a No. 20 (2 inches long) through which a smaller caliber (No. 25, 2 1/2 inches long) needle is passed may be used.

(4) Before the injection needle(s) is/are advanced into the nucleus pulposes of the intervertebral disk, AP and lateral projections are exposed without changing the position of the patient. These films are made to check the exact position and alignment of the needle(s).

(5) The patient is cautioned not to move; cough, or talk while the needle is in place. A syringe filled with the contrast medium (sterile aqueous solutions containing 50 percent iodine compound) is attached to the needle and approximately 0.2 to 0.5 cc of the contrast medium is injected into each of the intervertebral disks to be studied.

(6) AP and lateral projections (also oblique projections, if indicated) of the cervical region are obtained without changing the position of the patient. The films are processed for immediate inspection.

(7) If injection of additional contrast solution is not required, the injection needles are removed and further radiography is carried out according to the instructions of the examiner. Sterescopic exposures are made as indicated.

(8) All exposed films should be developed and presented to the examiner for inspection before the patient is returned to the ward.

Continue with Exercises

EXERCISES, LESSON 3

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the question or best completes the incomplete statement.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. The sharpest angiographic needle is:

   a. Plastic sheath type.

   b. Seldinger style.

   c. Venipuncture type.

   d. Arterial catheter.

2. One very important factor needed in angiographic equipment is:

   a. Low mA capacity.

   b. High tube heat capacity.

   c. Slow-speed timing unit.

   d. Tri-plane setup.

3. For angiography, the CR is usually directed:

   a. Vertically only.

   b. Horizontally only.

   c. Both vertically and horizontally.

   d. 20º caudad.

4. Angiographic examination usually requires about _____ kVp than that normally used for a given part.

   a. 10 percent less.

   b. 5 percent less.

   c. 5 percent more.

   d. 10 percent more.

5. What is the usual position of the arm for the start of arteriography of the upper extremity?

   a. Flexed with hand on abdomen.

   b. Adducted and pronated.

   c. Adducted and supinated.

   d. Abducted and supinated.

6. Where is the site of injection for the contrast medium in arteriography of the upper extremity?

   a. Over the cisterna magna.

   b. Over the brachial artery.

   c. Over the carotid artery.

   d. Over the femoral artery in the groin.

7. In venography of the upper extremity, what position does the patient assume initially?

   a. Supine.

   b. Prone.

   c. Sitting.

   d. Lateral recumbent.

8. Valsalva's maneuver and Muller's maneuver are actions that are performed by the:

    a. X-ray specialist.

    b. Radiologist.

    c. Injector.

    d. Patient.

9. In arteriography of the lower extremity, what technique is used to equalize exposure between thicker and thinner ends of the extremity?

    a. Reduce SID.

    b. Flex lower leg.

    c. Increase kVp.

    d. Place cathode end of tube nearest thigh.

10. In an upright venographic examination of the lower extremity, what supportive device should be used for the safety of the patient?

    a. Immobilization band.

    b. Sandbags.

    c. Shoulder rest.

    d. Head clamps.

11. Which of these areas would be a possible site for the injection of medium in a venographic study of the lower extremity?

    a. Popliteal.

    b. Intercondylar.

    c. Suprastellar.

    d. Retromalleolar.

12. In angiocardiography, what pair of views is usually performed with the biplane rapid film unit?

    a. Right and left laterals.

    b. AP and PA.

    c. AP and lateral.

    d. PA and PALO.

13. In the retrograde method of aortography, the patient is placed in what position?

    a. Supine.

    b. Fowler.

    c. Trendelenburg.

    d. Erect.

14. For vertebral arteriography, in what position is the patient placed?

    a. Supine, with head hyperextended.

    b. 20º Trendelenburg.

    c. Ventral decubitus.

    d. 45º Fowler.

15. In vertebral arteriography, what view is the basic projection?

    a. AP.

    b. Submentovertical.

    c. PA.

    d. Oblique.

16. Lymphangiographic study of the lower extremities will include radiographs of the:

    a. Abdomen and chest.

    b. Skull and sinuses.

    c. Cervical and thoracic spines.

    d. Auditory ossicles and hyoid bone.

17. In the routine ventriculographic procedure, what contrast medium is used?

    a. Mercury.

    b. Pantopaque.

    c. Visciodol.

    d. Carbon dioxide.

18. In the Waggoner-Clark position for ventriculography, the coronal plane of the head is angled _____ degrees from the vertical.

    a. 85 to 90.

    b. 70 to 75.

    c. 45 to 50.

    d. 10 to 15.

19. What general technical consideration would be in effect for all exposures made during ventriculography?

    a. Supervoltage technique.

    b. Horizontal CR.

    c. Short exposure time.

    d. SID 6 to 7 feet.

20. What is the purpose of the Queckenstedt test performed in myelography?

    a. Determine spinal fluid pressure.

    b. Determine intercranial pressure.

    c. Determine if a block is present in vertebral canal.

    d. Rule out osteomyelitis.

21. When the contrast medium is being aspirated in myelography, what action by the patient aids the flow?

    a. Forcing head against knees.

    b. Rocking on his abdomen.

    c. Forcing breath against closed glottis.

    d. Forcing head back against hands.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 3

1. c (para 3-8a(1))
2. b (para 3-9c)
3. c (para 3-17a)
4. d (para 3-18a)
5. d (para 3-19a(2)(a))
6. d (paras 3-19a(2)(c), (3)(b))
7. a (para 3-19a(2)(a))
8. d (para 3-19b(4)(b))
9. d (para 3-20a(2)(a))
10. a (para 3-20b(2)(c))
11. d (para 3-20b(3)(a))
12. c (para 3-21d)
13. a (para 3-23b(1)(a))
14. a (para 3-24d)
15. b (para 3-24d)
16. a (para 3-27b)
17. d (paras 3-29b(1), (2))
18. c (table 3-2)
19. c (para 3-29c(6))
20. c (para 3-30d(2))
21. c (para 3-30i(2))

End of Lesson 3

LESSON ASSIGNMENT

LESSON 4	Special Radiographic Procedures
TEXT ASSIGNMENT	Paragraph 4-1 through 4-48.
LESSON OBJECTIVES	After completing this lesson, you should be able to choose correct answers to questions about about: Mammography. Obstetrical radiography. Radiographic demonstration of fluid levels. Pediatric radiography. Tomography. Orthoradiology.
SUGGESTION	After completing the assignment, complete the exercises at the end of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 4

SPECIAL RADIOGRAPHIC PROCEDURES

Section I. MAMMOGRAPHY

4-1. INTRODUCTION

Radiographic examination of the female and male breast is known as mammography. This examination is used for the investigation of pathological symptoms to detect the nature and causes for those symptoms, to differentiate between benign and malignant tumors, and to determine a course of treatment.

4-2. ANATOMY AND PHYSIOLOGY OF THE BREAST

Functionally, the female breasts are accessory glands of the reproductive system. Several types of tissue occur in varying amounts, depending upon the age and physical condition of the patient.

a. **The External Structure.** The surface components of the breast include the skin, the areola, and the nipple. Usually, the breasts extend from about the second rib to the sixth or even seventh rib and from the lateral margins of the sternum to the axilla. Although breasts differ in size, the average craniocaudad (vertical) diameter is between 12 to 14 cm while the transverse (horizontal) diameter is slightly larger. In figure 4-1, note the structures of the breast, specifically the areola and the nipple. The nipple is a projection of areolar tissue on the apex of the breast. Its tip is perforated by 15 to 20 tiny orifices to the lactiferous tubules.

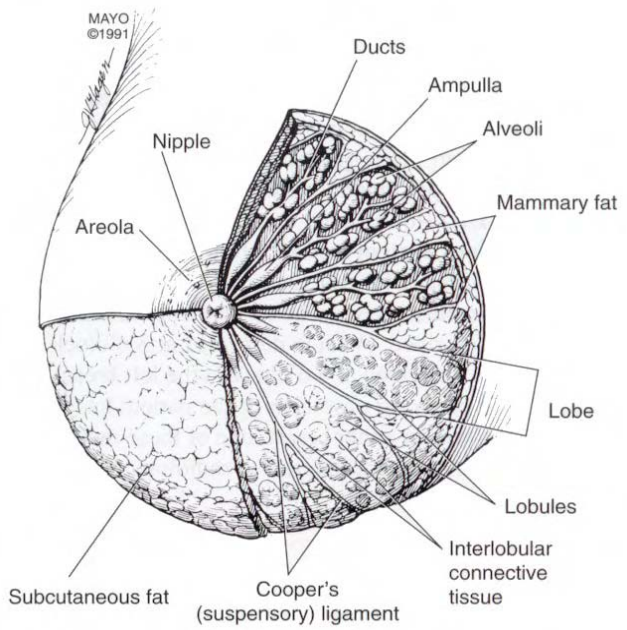


Figure 4-1. Breast diagram showing the breast structures.

b. **The Internal Structure**. The inner components of the breast are comprised of fibrous, glandular, and fatty tissue. They are augmented by a segment of the vascular system that includes a rather extensive lymphatic network. The intercostal and pectoral muscles form the breast wall.

(1) The fibrous tissue consists of two layers of fascia suspensory ligaments and an irregularly-pitted framework for the glandular tissue. The fascia layers, superficial and deep, are joined and completely house the mammary gland. The suspensory ligaments are vertical hands of elastic fibrous tissue that pass through the glandular tissue and connect the deep layer of fascia with the skin. The remainder of the fibrous tissue comprises the honeycombed framework for the mammary gland.

(2) The mammary gland consists of 15 to 20 lobes, each of which is composed of numerous lobules. All are interconnected by the lactiferous ducts, which form a distinct network. The tiny ducts from the lobules, called terminal ducts or acini, empty into the larger main ducts. These, in turn, empty into the lactiferous tubules that extend from each lobe into the nipple.

(3) Fatty tissue completely surrounds and is distributed in the glandular tissue in varying amounts, depending upon the patient's age and obstetrical condition. Figure 4-2 shows the internal structure of the breast.

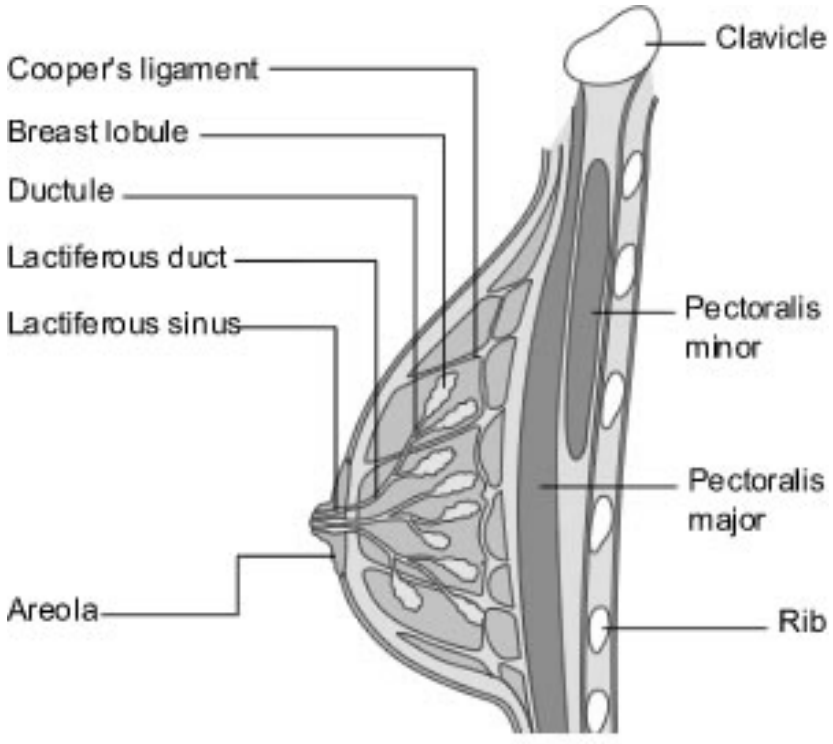


Figure 4-2. Internal structure of the breast.

c. **Structural Variations.** Structural variations result in the breasts being classified as virginal, adult (mature), lactating, menopausal, or atrophic.

(1) The virginal breast. The virginal breast appears relatively dense on a mammogram because it consists mainly of fibrous and glandular (fibroglandular) tissue. Minimal subcutaneous fatty tissue is present which accounts for the radiolucent margin.

(2) The mature breast. The mature breast usually has the widest variation in appearance on a mammogram. The reason is that there is a somewhat equal balance between fibroglandular and fatty tissue. The mature breast can be considered average in terms of density.

(3) The lactating breast. The glandular tissue proliferates and becomes engorged with milk secretion during and after pregnancy. During the period, the glandular tissue compresses the fibrous tissue and causes an increase in both size and density of the breast. The breast is denser during the lactation period than it is at any other stage. Following the lactation period, however, density decreases when the need for fluid is gone and both the lobes and ducts decrease in size. At the time, fatty tissue begins to develop and fills the space formed by expansion.

(4) The menopausal breast. As a woman approaches and passes through the age of menopause, commonly called "change of life," the structure of the breast is again modified. Hormonal stimulation of the glandular tissue progressively decreases, which results in a gradual loss of both glandular and fibrous tissue. These tissues are replaced, in part, by fatty tissue, the breast becomes softer, and there is less fibroglandular tissue.

(5) The atrophic breast. As the menopausal stage progresses, fatty tissue continues to replace fibroglandular tissue until the breast is comprised solely of fatty tissue. When this transition is complete, the breast is referred to as being atrophic.

4-3. FOCAL-SPOT SIZE

There are two important factors to consider when selecting the focal spot to be used in mammography. The first, and perhaps most important, consideration is the capacity of the tube to withstand the heat generated in a single exposure. Naturally, a large focal spot can tolerate higher exposures than a small one. Consequently, when high exposure factors are used, it may be necessary to use a large focal spot. However, if the exposure factors are low enough to permit the use of a small focal spot, then it should be used. Remember, a smaller focal spot gives better detail, and detail on a mammogram is extremely important.

4-4. ANODE STORAGE CAPACITY

To produce the desired contrast on a mammogram, it is necessary to use low kVp. Low kVp in conjunction with high mAs (which is generally used in mammography) produces a tremendous amount of heat in the tube. For example, suppose the technique for a single projection is 26 kVp and 1,800 mAs. This would produce 46,800 heat units (HU) (26 X 1,800 = 46,800). Since three views of each breast are normally included in a mammography study, the total would be 280,800 HU (6 X 46,800 = 280,800). The anode storage capacity of most x-ray tubes is considerably less than the 280,800 HU in the hypothetical case described above. Therefore, to prevent damage to the anode, it would be necessary to allow the appropriate cooling time between exposures. Cooling times is based on the anode-cooling curve found on the tube-rating chart.

4-5. FILTRATION

Radiographic demonstration of the differences in breast-tissue density requires a soft, heterogeneous x-ray beam. Ideally, then, mammography should be accomplished with absolutely no filtration. However, in the interest of keeping patient dosage to a minimum, NCRP (National Council on Radiation Protection and Measurements) Reports No. 33 requires certain amounts of filtration for all radiographic examinations. For operating voltages up to and including 50 kVp, the report requires at least 0.5 mm aluminum equivalent. Standard x-ray tubes may or may not have the required 0.5 mm aluminum equivalent in the form of inherent filtration. If not, additional filtration to achieve this standard must be added. Some special-purpose tubes usually have less than 0.5 mm inherent filtration. For example, a beryllium-window tube only has from 0.1 to 0.3 mm. When filtration must be added, use clear plastic to avoid blocking the filament flow since "light" from the filament helps in positioning the cone.

4-6. BEAM-RESTRICTING DEVICES

SR (scatter radiation and secondary radiation) must be kept at a minimum because it can cause film fogging that is degrading to radiographic detail. To reduce SR and to keep the skin dose to the patient at a minimum, the primary beam should be restricted so that it covers the breast. Extension cylinders, modified collimators, and specially constructed cones are used to restrict the x-ray beam.

4-7. FILMS

Standard, coarse-grained radiographic films are inadequate for the fine detail required in mammography; thus, fine-grained or special mammography films are used. Some radiologists prefer to use a "package" of two or more films. By using films of various speeds, visualization of the deep fibroglandular structures as well as of the peripheral anatomy is provided. Some mammography films can be processed automatically while other films must be processed.

4-8. TECHNICAL FACTORS

a. The technical factors used in mammography depend upon several variables. Such things as film speed, output characteristics of the x-ray tube, tube capacity, and filtration must be considered. The kVp should be 20 to 35 (except for the axillary projection) because, in this range, the small differences in photon absorption are enough to provide adequate contrast. SID can be from 18 to 40 inches. As a general rule, the mAs can be as much as 1800, depending upon the kVp, SID, and the speed of the film. For example, using type M film with 26 kVp and 36-inch SID, the mAs would be about 1800. On the other hand, if the same kVp and SID were used with type AA film, less mAs would be required because type AA is faster than type M.

NOTE: Check with the manufacturer for specific technique ranges.

b. Normally, when establishing a technique, it is only necessary to determine the factors for the craniocaudad projection of a medium-sized mature breast. Variations in technique because of breast size, breast density, and projection can be determined from the initial factors.

c. One method for establishing a technique is to make trail exposures of an aluminum step wedge with the central ray directed to the 15 mm step. Using predetermined mAs and SID, depending upon the film speed; the kVp is varied until the 15 mm step is faintly penetrated. This setting is used for the craniocaudad projection.

d. For the mediolateral projection, 2 kVp are added to the craniocaudad kVp, with the remaining factors unchanged. The axillary projection requires about 50 kVp.

NOTE: The kVp cannot exceed 50 if only 0.5 mm aluminum-equivalent filtration is used.

e. The density of the breast also requires variation in technique. Usually, a change of about 2 kVp is enough to compensate from one density category to the next. For example, if 28 kVp is used for a mature breast, 26 kVp would suffice for a menopausal breast.

f. As a general rule, the requirement for altering the technique to compensate for the different breast sizes is just the opposite from most other examinations. For example, a larger breast usually contains a greater proportion of fatty tissue and lies flatter on the film holder. Consequently, less technique is required. Smaller breasts usually contain a greater proportion of fibroglandular tissue and require more technique. One good way to compensate for these differences is to take advantage of the inverse square lay by altering the SID. This method also allows precise restriction of the primary beam, which (as previously mentioned) is important. To put this in perspective, consider the following comparison between a medium-sized breast and a large breast.

(1) The large breast usually requires both a larger cone field and a decrease in technique. By increasing the SID over that used for the medium breast, both of the requirements are met.

(2) Two exceptions to this method are the small breast containing mostly fatty tissue and the large breast containing mostly a fibroglandular tissue. These are usually identified by the x-ray specialist before the examination and appropriate compensations are made.

4-9. PATIENT POSITIONING

The projections most commonly used for mammography studies are: craniocaudad, mediolateral, and axillary.

a. **Craniocaudad.** In figure 4-3, the major considerations associated with the craniocaudad projection are illustrated. When positioning a patient for this projection, use the following as a guide.

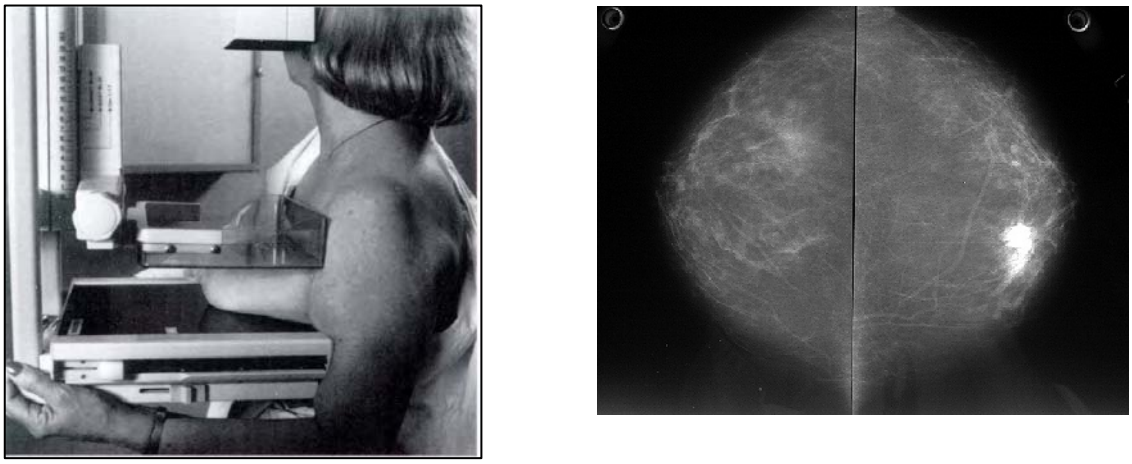


Figure 4-3. The craniocaudad projection, position and mammogram.

(1) The patient must put on a gown with the opening in front. (Use surgical gowns or isolation gowns if the x-ray gowns do not open.)

(2) Have the patient sit on an adjustable (rotating type) stool.

(3) If available, use a room containing a table with horizontally sliding top. This allows the patient to sit under the tabletop, making it possible to get very close to her chest.

(4) Place the film holder very close to the patient's chest. It must be touching. If it is flexible, you may bend it slightly under.

(5) Have the patient place her hand behind her back.

(6) Bend her slightly backward and place the complete breast on the cassette.

(7) Position the tube so that the CR is directed to the midpoint of the base of the breast.

b. **Mediolateral.** Figure 4-4 illustrates the mediolateral projection. The procedures are as follow.

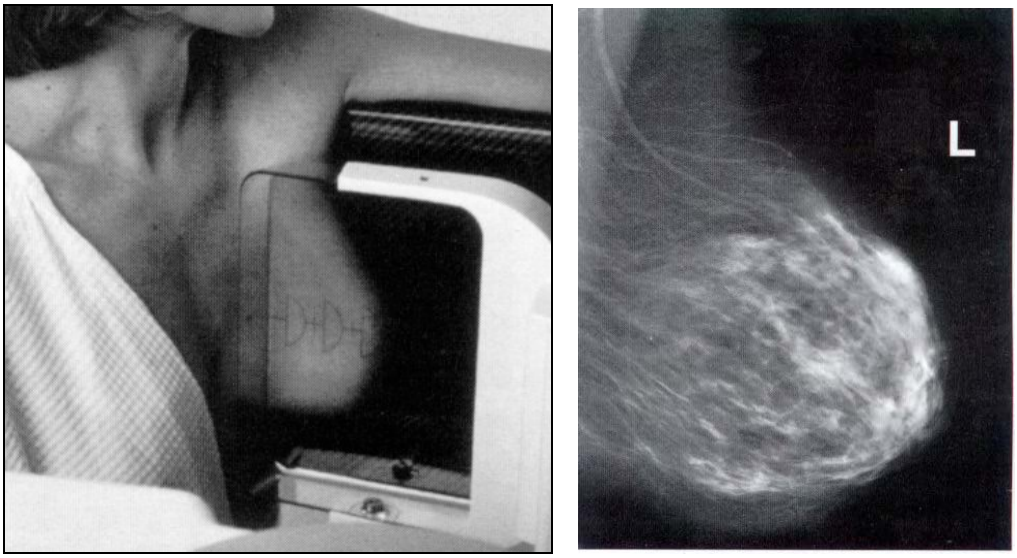


Figure 4-4. The mediolateral projection, position and mammogram.

(1) Unless there is a special apparatus for mammography procedures, the mediolateral is best taken with the patient on the radiographic table top, lying on the side (laterally recumbent).

(2) Place a pillow or cushion beneath her head and shoulders. A positioning block (square or triangular, whichever is better) is placed beneath the cassette. This puts the breast in a true lateral position.

(3) Have the patient hold the opposite breast close to her chest so that it will not be superimposed over the breast being x-rayed. The hand on the projection side should be placed beneath her head.

(4) The film is placed in a position to completely cover the breast. Two projections may be taken on one film if the breast size will permit.

(5) The CR is directed to the midpoint of the base of the breast.

c. **Axillary.**

(1) Figure 4-5 demonstrates the axillary position. With the patient supine on the table, the film is positioned so that the axillary area, the tail of the breast, and the upper quadrant of the breast are included on the film.

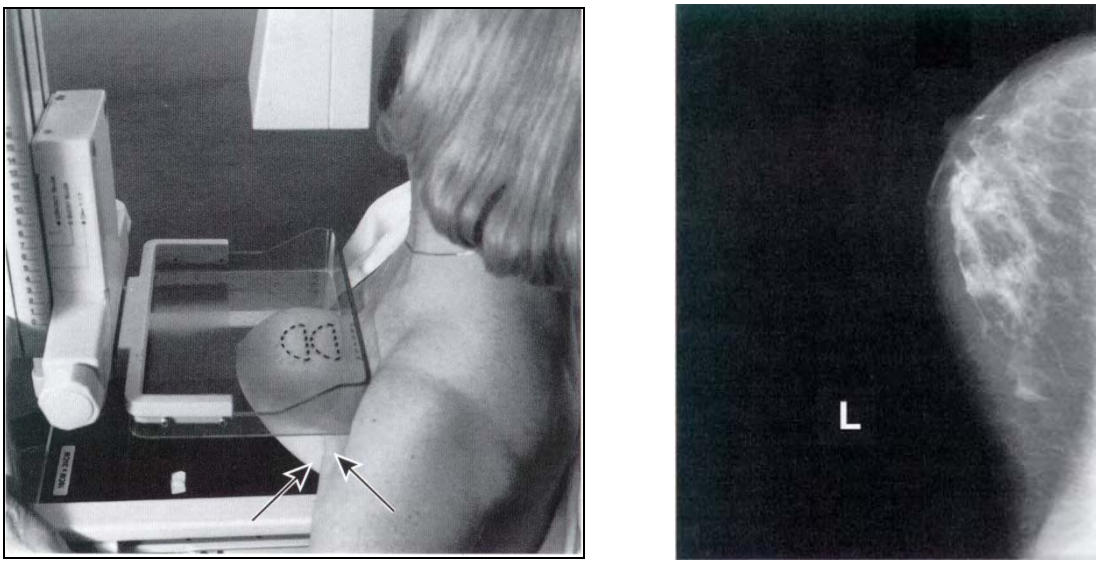


Figure 4-5. The axillary projection, position and mammogram.

(2) The patient is rotated toward the side being examined until the tail of the breast is projected beyond superimposition of the chest wall (body rotation is usually between 15 and 30 degrees).

(3) The CR is directed perpendicularly to the film.

4-10. GENERAL CONDITIONS

a. **All Projections.**

(1) Always place the identification markers along the axillary margins of the film. This will help the radiologist maintain orientation as he interprets the film.

(2) Ensure that coning is such that the breast is demonstrated in a constricted cone field. The light from the filament will indicate the cone field.

(3) Ensure that the patient's position is as comfortable as possible so she can more readily maintain the position throughout the exposure.

(4) Wait until you are ready to make the exposure before giving the patient breath control instructions. The longer she must hold her breath, the greater the chance for involuntary motion.

(5) Make both projections of each position on the same film when possible (that is, both craniocaudad, both mediolateral, et cetera).

b. **Craniocaudad.**

(1) Ensure that the film holder is in close contact with the chest wall. Such placement will result in demonstrating the maximum amount of breast tissue.

(2) Have the patient sit up straight and even lean backwards a bit to preclude superimposition of the clavicle over the breast.

c. **Mediolateral**. Make sure that the opposite breast does not overlie the one being examined. At times, it may be necessary to have the patient hold the opposite breast to preclude such superimposition.

Section II. PEDIATRIC RADIOGRAPHY

4-11. INTRODUCTION

Pediatric radiography deals with infants and children up to 12 years of age. With certain exceptions, the basic fundamentals of the technique are substantially the same as for any other age group.

4-12. HANDLING OF INFANTS AND SMALL CHILDREN

The handling of infants and small children requires special care and patience on the part of everyone concerned in the examination. When it is apparent that an infant or a small child is going to be difficult to manage, it may be helpful to have one of the parents or a family friend remain in the room during the examination. However, in some cases, it may be best to have a nurse or other attendant help to manage the intractable child while the relatives remain elsewhere.

4-13. PHYSICAL FACTORS

a. **Size.** The factor of size is a definite problem in estimating exposure techniques, but it affords certain advantages in the shorter SID can be used without incurring excessive image distortion. When the x-ray tube has a relatively low mA capacity, the shorter SID permits the use of a shorter exposure time. Also, the size of the patient will determine the size of the film to be used. The factor should always be considered before going to the ward for bedside radiography.

b. **Tissue Density and Tissue Contrast.** Radiography of an infant's chest normally requires a higher range of x-ray intensity in relation to a given part-size than in the case of an adult. This is mainly due to the difference in the ratio of aerated to non-aerated tissue in the thoraces of infants and adults. The opposite is the case for the other parts of the body; that is, for a given part-size, less exposure energy normally is required for a very young patient. The foregoing facts should be carefully evaluated when it is necessary to modify tabular exposure techniques that are based on factors scaled for routine radiography of adults.

c. **Motion.** The greatest obstacle to overcome in the normal course of pediatric radiography is the adverse effect of motion--whether voluntary or involuntary. In a young child (and especially in an infant), respiratory and cardiovascular motions are much more rapid than in the average adult patient. The most effective method for overcoming this limiting factor is by reduction of the exposure time.

d. **Susceptibility to Infection.** The x-ray specialist should always wash his hands thoroughly before handling any pediatric patient. If suffering from a minor respiratory complaint, he should wear a mask.

4-14. RADIOGRAPHIC PROCEDURE

a. **Preliminary Procedure.** The selection of technique factors, films, work-up of identification material, and other necessary preparations should be completed before the patient is brought into the exposure room. This will enable the x-ray specialist to give his full attention to the handling of the patient. Calling the ward for pediatric patients should be deferred until it is certain they can be given immediate attention.

b. **Positioning.**

(1) For the most part, the positioning procedure for pediatric patients should conform to the essential technical considerations prescribed for the standard positions with respect to a given examination.

(2) Awkward positions should be avoided. Whenever possible, advantage should be taken of unorthodox angulations or positions of the x-ray tube.

(3) Unless otherwise indicated, examination of the extremities for a given view should b done bilaterally, preferably by simultaneous exposure on the same film.

(4) In chest examinations, it is advisable to make two films, one at inspiration and one at expiration.

c. **Immobilization.**

(1) The assistance of one or more persons other than radiological personnel may be enlisted to aid in immobilizing the patient according to the demands of the particular situation.

(2) A strap made of clean cotton webbing, 2 inches wide and about 2 1/2 to 3 feet in length, should be provided for immobilization of the skull in the lateral position. When this is needed, an assistant holds the strap tautly across the frontal and parietal areas with the head turned to be lateral position. If such a strap is not available, a suitably folded hand towel can be used.

(3) A pair of large-sized synthetic rubber sponges held firmly against the sides of the patient's head may be of considerable help in obtaining AP or PA projections of the skull with the least likelihood of the assistant's hands being superimposed on the image.

(4) A suitable modification of the Sayre apparatus ("head sling") may be used to considerable advantage for radiography of the head or neck with the patient in the upright position.

(5) In certain cases, it may be helpful to snugly wrap the patient's body (from the shoulders down with the arms alongside the body) in a suitable sheet. This procedure is often referred to as "mummification."

d. **Precautions.**

(1) Lead-impregnated aprons, gloves, and protective shielding must be provided for protection against irradiation for persons assisting in the immobilization of the patient during exposure. The area of irradiation should be confined to the most practicable limits by the proper use of cones, cylinders, diaphragms, or collimators. Under no circumstances should an x-ray specialist hold a patient during exposure. Gonads should be protected with lead shields when practicable.

(2) Under no circumstances should the patient be left unattended for any length of time while on the x-ray table or in a crib with the guard railing down. The danger of the child falling off the table or out of the crib is very great.

(3) Loose articles that can be swallowed, such as diaper pins or identification materials, should be kept out of reach of the child at all times.

(4) If the patient is being held in an immobile position by an assistant, the x-ray specialist should not make the exposure until he has made sure that the assistant's hands are not interposed over any area of the patient in line with the path of the exposing x-ray beam.

(5) When verbal communication is possible, the instructions as to breathing control should be as simple and short as possible. Remember that children have a very short span of attention. When necessary, crying may be induced in infants and the exposure made at the beginning of the cry.

e. **Use of Contrast Media.**

(1) For gastrointestinal examination of infants, approximately 4 ounces of barium sulfate and 5 percent sterile glucose water should be prepared in sterile nursing bottle. Several sterile nipples with openings of different sizes should be provided to meet the demands of particular situations. The preparatory phase of the examination is carried out according to clinical dictates. Usually, food and fluids are withheld approximately 4 hours prior to examination. Incidental fluoroscopy and radiography will be done according to the directions of the radiologist. In children over 2 years of age, the examination is normally carried out in a manner similar to that for an adult.

(2) The contrast medium used for esophageal studies may be the same as that used for gastrointestinal examinations. The contrast substance may be introduced by ingestion from a nursing bottle or by way of a suitable catheter attached to a syringe and transnasally inserted into the esophagus. Radiography is frequently limited to spot-filming.

(3) For barium enema examinations, a suspension consisting of barium sulfate and water is introduced under fluoroscopic control throughout the anus via a suitable catheter. Retention of the contrast substance in the bowel may be facilitated by holding the buttocks together with adhesive tape. Incidental radiography or spot-filming is carried out according to the directions of the radiologist.

(4) The techniques for other contrast studies (such as intravenous and retrograde pyelography, cystography, and urethrography) are essentially the same as for adult patients. The chief difference is that the amount of contrast media used in pediatric radiography is scaled to the size and age of the individual patient. In certain examinations, infants and children under 5 years of age are examined on the horizontal fluoroscopic or radiographic table.

f. **Radiographic Measurements.** Radiographic measurements for determining the exact length of certain body structures, such as the long bones, may be done by means of one of the orthoradiographic techniques.

g. **Bone Age.** At times, it is necessary to x-ray children to determine the bone age. The x-rays are compared with growth charts found in many publications to find out if the growth process varies from normal. The radiographs taken depend entirely upon the radiologist. PA hands and wrists and dorsoplantar feet are commonly employed. Others include AP projections of joints such as elbows, shoulders, hips, knees, and ankles.

h. **Technique factors.** The technique adjustments in Table 4-1 are intended as a starting guide only. Specific technique factors are listed for certain age groups and fractional designations are given for other age groups. The fractional designations refer to corresponding technique factors scaled for average adult patients. For example, "1/3 basic mAs" means that the technique factors customarily used for comparable examinations of adult subjects remain constant, except that the mAs value is reduced to one-third. This is not to imply that changing the mAs is the only way to adjust the technique. The kVp, or both mAs and kVp, can be adjusted to provide satisfactory results.

Pediatric Adjustments To Technique	
0-1 year	Use 1/4 x mAs
2-4 years	Use 1/3 x mAs
5-11 years	Use 1/2 x mAs
12+ years	Use Adult technique

Table 4-1. Pediatric radiography: Suggested starting technique factors for ages 0 to 12 years.

Section III. TOMOGRAPHY

4-15. INTRODUCTION

a. Since the introduction of computed tomography (CT) and magnetic resonance imaging (MRI) with their excellent contrast resolution, tomography is less frequently used. Conventional methods of radiography often resulted in the superimposition of images on a two-dimensional film. To demonstrate a particular layer of the body unobscured by images of overlying and underlying structures, a special technique known as tomography can be employed. Tomography is now applied principally to high-contrast procedures such as imaging the calcified stones in the soft tissues of the kidney.

b. Tomography (body-section radiography) encompasses several methods by which a specific layer of the body can be demonstrated to the exclusion of overlying and underlying structures. Images of objects lying in other planes are eliminated, or at least minimized, by blurring. For example, a lesion in the chest may be radiographed free of overlying rib shadows. Figure 4-6 is an example of a tomogram of the temporomandibular joint.

c. Tomography is a useful technique in all phases of radiography and can reveal the correct diagnosis in many instances when it would otherwise be missed. It can be used successfully with and without contrast media and plaster casts.

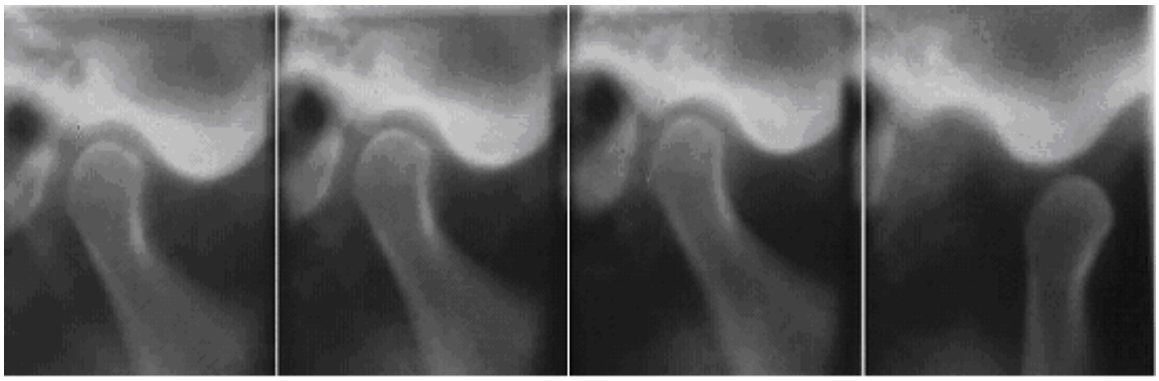


Figure 4-6. A series of radiographs of the temporomandibular joint produced by tomography. The mouth is closed in the first three images and open in the fourth.

4-16. TOMOGRAPHIC SYSTEMS

Radiography of a layer or section of the body is known by many names such as tomography, stratigraphy, laminagraphy, and planigraphy. As a general rule, the names were applied to the patented apparatus. However, the basic principles of operation are the same. To standardize the nomenclature, the International Commission on Radiological Units and Measurements (ICRU), in Handbook 89, recommends that tomography be used to describe all body-section techniques. Handbook 89 further classifies the systems according to the methods involved. This study guide describes two moving tube systems, called rectilinear and pluridirectional.

a. **Linear.** The tube and film move in a straight line. This movement can be described as plane-parallel. Some tomographic apparatus will only perform a linear movement longitudinally to the long axis of the table. Others will perform crosswise and diagonal movements with respects to the long axis of the table. See figures 4-7 and 4-8. Linear movements are often adequate for tomograms of the lungs, kidneys, and simple bony structures.

b. **Pluridirectional.** Pluridirectional (multidirectional) systems, as a general rule, produce better tomograms of areas that require maximum blurring, such as the optic canal, inner ear, and complicated bone structures. In polytomography, the term is usually used for pluridirectional system in which there is a wide variety of movements. They include circular, elliptical, hypocycloidal, spiral, sinusoidal, and random movements. The first three of these are discussed below.

(1) Circular. Although the circular movement is the simplest of the polytomographic movements, it offers complete blurring. Circular movement is accomplished with the tube tilted 20º to 40º. The pattern is beneficial for views of the lumbar spine.

Figure 4-7. Tomography.

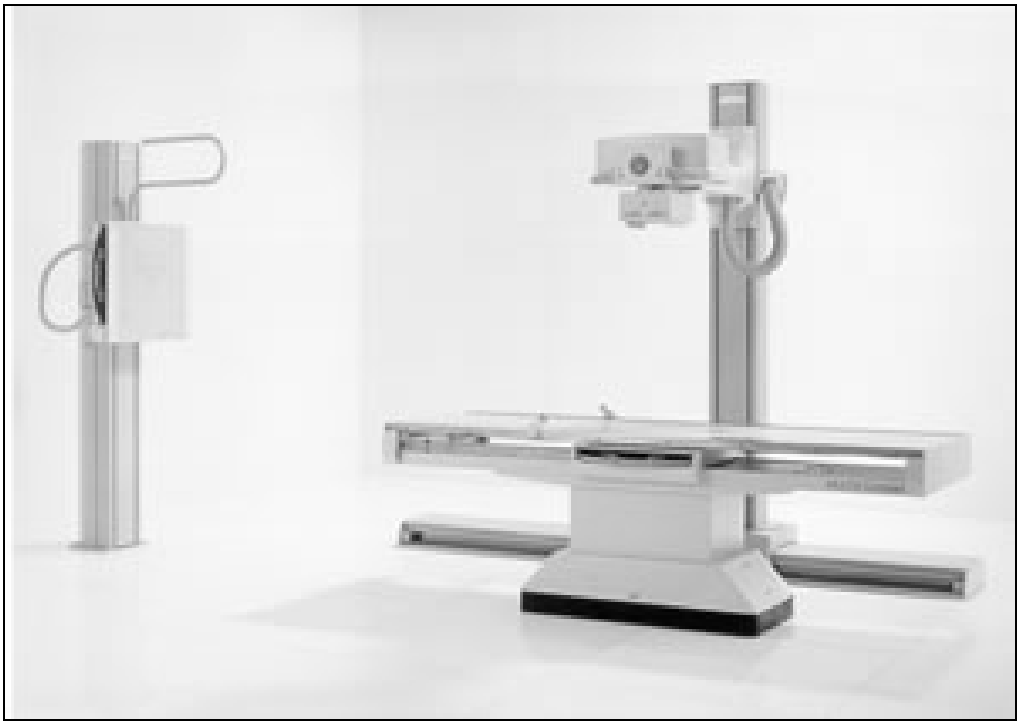


Figure 4-8. An apparatus designed for tomography.

(2) Elliptical. The elliptical movement appears as an oblong circle. Most polytomographic units will produce an elliptical movement longitudinally, crosswise, or diagonally to the long axis of the table. It is usually used for lateral projections of the lungs. It is also excellent for studies of the cervical and dorsal spines.

(3) Hypocycloidal. Hypocycloidal is the most complex of the polytomographic movements. It makes a pretzel-like cut that produces the most complete blurring. Virtually all overlying and underlying structures, bony or otherwise, can be totally obscured by this movement. It can be used for skull detail and is excellent for joint spaces.

4-17. PRINCIPLES OF TOMOGRAPHY

a. **Apparatus.** Basically, a rectilinear tomographic apparatus consists of a standard radiographic table, a movable cassette tray, and a movable tube head. (Polytomographic apparatus is designed specifically for polytomography and is much more complex than rectilinear apparatus.) The tube head and the cassette tray are attached to opposite ends of a vertical bar which is provided at a selected point between the tube and the cassette tray.

b. **Fulcrum Point.** The point or level at which the vertical bar is pivoted is known as the fulcrum point. At this point, there is controlled minimum motion. This is the operating principle of tomography; above and below this point, there is motion when the tube is moved. The fulcrum point also determines the focal plane.

c. **Focal Plane.** The level or plane of the body section to be examined is known as the focal plane or datum plane. The level corresponds to the fulcrum point.

d. **Operation.** As the tube travels in one direction, the cassette tray travels in the opposite direction. The exposure is made during this movement. Shadows of the image at the focal plane will appear on the same area of the film throughout the movement and exposure. This is true because at the fulcrum point or focal plane, there is minimal movement. On the other hand, the shadows of all other planes below and above the focal plane will be projected on different portions of the film during the movement. The result will be a sharp and discernible image at the focal plane. All other images will be blurred out and therefore, indistinct.

4-18. FACTORS OF SECTION THICKNESS

The thickness of the layer, commonly referred to as the cut, is measured in millimeters (mm) and is controlled by two factors: the amplitude of tube travel and the SID.

a. **Amplitude.** Amplitude is the distance, in inches, that the tube travels during the exposure. A short amplitude will project a thick section; a long amplitude will project a thin section. Amplitude is usually automatically set when a particular movement is selected on polytomographic units. On rectilinear units, the amplitude must be set manually.

b. **Focus-film Distance.** When the amplitude remains constant, the shorter the SID, the thinner the section. This is true because more tube movement (and consequently more blurring) occurs in the planes above and below the focal plane. On the other hand, the greater the SID, the thicker the section.

4-19. MILLIAMPERE SECONDS

Because of the increase in part thickness due to tube movement, the mAs (milliampere seconds) must be increased from 50 percent to 100 percent over the mAs normally used in radiography for the same body part.

4-20. EXPOSURE TIME, AMPLITUDE, AND RATE OF TUBE TRAVEL

In polytomography, amplitude and rate of tube travel are automatically set when a particular tube movement is selected. Exposure time for each movement is found in the manufacturer's operating manual. In rectilinear systems, the three factors can usually be adjusted to fit the situation.

a. **Exposure Time.** To find the exposure time when the amplitude and the rate tube travel (in inches per second) are known, divide the amplitude by the rate. The formula is expressed as follows:

$$\text{Exposure} = \frac{\text{Amplitude (distance of tube travel)}}{\text{Rate of tube travel}}$$

EXAMPLE: If the amplitude is 15 inches and the tube is to travel 10 inches per second, then the exposure time would be 1.5 sec.

b. **Amplitude.** When the exposure time and the rate of tube travel are known, multiply them to find the amplitude as follows:

$$\text{Amplitude} = \text{Rate of the travel} \times \text{exposure time}$$

EXAMPLE: If the rate is 10 inches per second and the exposure time is 1.5 sec, the amplitude would be 15 inches.

c. **Rate of Tube Travel.** When the amplitude and the exposure time are known, divide the amplitude by the exposure time to find the rate of tube travel, as follows:

$$\text{Rate of tube travel} = \frac{\text{Amplitude}}{\text{Exposure time}}$$

EXAMPLE: If the amplitude is 15 inches and the exposure time is 1.5 sec, then the rate would be 10 inches per second.

NOTE: There are still equipment sets in hospitals around the world where these calculations are needed. Most tomographic equipment today is computerized and performs the calculations for the technologist.

4-21. GENERAL PRINCIPLES

a. **Introduction.** For a tomographic examination, the patient is positioned on the table as for ordinary radiography. The part is measured and the basic exposure technique selected. Then a fulcrum point is selected on the basis of a lateral exposure to correspond to the level of the focal plane in centimeters. Usually, several exposures correspond to the level of the focal plane in centimeters. Usually, several exposures or cuts are made at different planes until the desired plane is demonstrated. In sections where tomographic units are available, precise operating instructions depend upon local policy. However, certain general instructions apply in most cases.

b. **Control of Image Detail.** Because of the blurring effect, the image is likely to have reduced sharpness unless you:

(1) Use the minimum source to image distance (SID).

(2) Select an SID of at least 30 inches.

(3) Use a small focal spot.

(4) Select an exposure technique that will provide adequate penetration.

(5) Ensure that the section is not more than 2 to 3 mm thick.

(6) Give the patient breathing instructions just before the exposure. Do not forget that tomographic exposures are longer than normal radiographic exposures. This gives the patient more time in which to breathe, thereby, increasing the possibility of motion.

c. **Positioning Instructions.** In polytomography, the tube movement is usually selected on the basis of how well it will demonstrate a particular body part. Many tomographic units, however, only have a rectilinear movement in one direction, longitudinally to the long axis of the table. With a rectilinear movement, it is necessary at times to alter the patient's position to achieve the best results. For maximum blurring, the superimposed structures should be at a 90º angle to the tube movement.

(1) If, for example, the ribs are under study, the patient should be positioned across the table. This will place the spine (the major superimposing structure) at a 90º angle to the tube movement; consequently, it will be blurred. But the ribs, positioned so that they are parallel to the tube movement, will be clearly demonstrated. When there are two major superimposing structures at right angles to each other, the patient may be positioned at an angle of 25º to 30º to the direction of tube travel. An example of this is the sternum. If the patient is aligned parallel to the tube travel, the spine will be parallel with the tube movement and will not be effectively blurred.

(2) If the patient is positioned across the table, the ribs will not be effectively blurred because the ribs will be parallel to the tube movement. The solution, then, is to position the patient so that both the ribs and spine, each about 25º to 30º to the direction of the table movement, will be blurred. This will provide a good demonstration of the sternum.

d. **Patient Preparation.** During an average tomographic examination, the patient will receive about the same amount of radiation that he would receive in a fluoroscopic and radiographic examination of the spinal canal (myelography). This is true because the mAs is increased and because several "cuts" are usually required in one examination. To minimize the amount of radiation the patient receives, you should see that a minimum of 4 mm of total filtration is provided.

Section IV. ORTHORADIOGRAPHY FOR SKELETAL SURVEYS

4-22. INTRODUCTION

a. Orthoradiography is a radiographic procedure whereby the factor geometrical distortion is eliminated or is minimized to such an extent that it is possible to record the exact form and size of structures inside the body. It is of particular value in obtaining accurate measurements of the long bones of the skeletal system. It may be used, for example, to determine the length of the femur prior to insertion of an intermedullary nail or to maintain an accurate record of progress or regress in certain pediatric cases.

b. In orthoradiography, a particular portion of the x-ray beam is used in such a way as to protect a specific dimension of an object in true size. The image produced, when measured, corresponds in size to the actual dimension of the object under consideration.

c. The major factors in the application of this principle are:

(1) Position of the source-point of radiation and focal-spot size.

(2) Alignment of the CR.

(3) Point on object under consideration.

(4) Film-object plane.

(5) Alignment of divergent rays in relation to CR.

d. Neither SID nor the OFD exert any significant influence on the outcome of the end result insofar as a specific dimension is concerned. Divergent rays falling in a plane in line with the CR and at right angles to the long axis of the object have the same dimensional validity as the CR. However, it is a good rule to keep the OFD (object film distance) to a practical minimum and the SID to a feasible maximum in order to obviate the penumbra effects due to focal-spot size and magnified distortion inherent in short SID.

4-23. METHODS

a. **General.** The principles of orthoradiography may be incorporated in numerous methods, depending upon the nature of the problem and the facilities available. The method most generally used to spot-scanography. The following methods are rarely used today, having been replaced by other modalities. They can still be encountered in some facilities.

b. **Spot-Scanography.** In spot-scanography, two "spot" exposures are made at specific points on the object. The film-object plan is parallel and the CR is perpendicular to the film plane. Film identification is "burned-in" after completion of the spot exposures. If the object under consideration is of such length that is overrides the film, the film may be placed diagonally with the long axis of the object. Measurements are made after the film is processed.

c. **Spot-Scanography in Combination with Calibrated Rule.** The method is identical to that described above, with the exception that a radiopaque calibrated rule is placed on the film alongside the object. This rule may consist of a strip of lead 3/4 inch wide and of sufficient length. One edge of the strip should be notched at 1-cm intervals. The lead strip should be mounted on a flat piece of wood or aluminum, to provide rigidity and ensure the maintenance of accurate length. Commercially produced rulers are available for this purpose. These measure 100 cm long, and are calibrated in 1-cm increments. Calibration markings and numbers are painted with lead-impregnated paint to provide visibility on the radiography. By using two separate films, this method

permits scanography of objects any length. When the rule is placed on the films, it should be aligned so that it is parallel with the long axis of the object under consideration. Cone coverage must be sufficient to demonstrate both the point on the object and the corresponding portion of the calibrated rule. Measurement is accomplished by aligning the point on the object with the known markings on the calibrated rule. Either non-Bucky or Bucky technique may be used. The calibrated rule should be placed on the tabletop. In this way, both exposures can be accomplished on a single film.

d. **Slit-Scanography.** This method is useful in that it produces an image that shows the object in its entire length. Any part or portion of the object may be measured. In slit-scanography. A narrow slit is used beneath the x-ray tube or the lip surface of a cone in such a way that a line or sheet of x-rays is used. As the x-ray tube moves over the object from one end to the other, the rays of the central beam pass through the part at the same angle. A sheet of lead, about 3/16 inch in thickness and a proper size to fit into the slot under the tube where filters are generally inserted, may be used. The width of the slit-should be about 1/4 mm. The length of the cut in this piece will depend on the extent of lateral coverage desired or necessary in relation to the long axis of the object. For detail information on this method and other methods of orthoradiography, the x-ray specialist should consult standard texts.

Section V. THE SKELETAL SYSTEM

4-24. GENERAL

One of the most important, yet frequently overlooked, aspects of radiography is the dealing with the skeleton as a system rather than as a unit made up of individual components. For example, bone radiography of the upper extremity is usually thought of in terms of a hand, a wrist, a forearm, a humerus, etc., rather than the entire extremity combined. Radiographs of these individual bone elements are usually made for the purpose of diagnosis as a direct result of trauma. Do not forget that the skeleton is often x-rayed as an indirect result of trauma or as the result of some impairment of the normal function of the skeletal system in the process of one growth. It is with broader viewpoint that radiography of the skeletal system is primarily concerned.

4-25. DEFINITION

Radiography of the skeletal system may be defined as the interpretation of the condition and relationship of the bony structures by means of radiographic visualization.

4-26. PURPOSE

The purpose of radiography is to demonstrate the general condition of the bony structures with regard to existing disease or with regard to the functional status. It can be used to:

a. Differentiate an anatomical short leg from a functional short leg.

b. Diagnose the various bone deformities caused by diseases such as scurvy, rickets, or other vitamin deficiencies and the various arthritic conditions.

c. Visualize any existing pathology including which may have metastasized from another area.

d. Determine the bone age of an individual in comparison to his chronological age.

4-27. CLINICAL PROCEDURE

Radiography of the skeletal system includes a number of examinations. The anatomical areas concerned govern the x-ray procedures used. Some of the more common examinations are described in paragraphs 1-7 through 1-11.

4-28. ARTHRITIC SURVEY

This survey will primarily be used to diagnose bone deformities in all areas of articulation caused by arthritis. The number of radiographs taken will be governed by the routine established in the specific clinic; however, the radiographs will always be taken of the primary joint spaces of the body. When a severe arthritic condition is found within one joint space of the body, it is very possible that other joint areas are also involved. It is for this reason that this survey has been established. In order to complete this survey clinically, it is customary to perform right angle viewing of the specific areas in question. Added suggested routines are as follows:

a. AP and lateral elbows, knees, and ankles.

b. Laterals only--cervical, dorsal, and lumbar spines.

c. AP pelvis.

d. Bilateral-PA hands and wrists, DP feet, and AP shoulders.

4-29. METASTATIC SURVEY

a. The usual sequence of a highly virulent disease, such as tuberculosis or cancer, is to involve not only the immediately affected area but also other areas of the body. This transfer of a disease from one organ or area to another is referred to as metastasis. When disease metastasizes to bone, usually the shafts or bodies of bony structures are the areas primarily involved. Accordingly, the x-ray procedure will be compensated to stress the primary areas of involvement. Here, too, because metastasis to any area is possible, a clinical routine must be established as to what specific views are to be taken and how many specific bones are to be included. Suggested routine: lateral skull, PA chest, AP and lateral dorsal and lumbar spines, and AP pelvis.

b. In addition, radiographs of organs or soft tissue surrounding the diseased areas must be made in order to establish whether or not the pathology has spread to adjacent tissues. The lungs constitute one of the most common areas of involvement. These organs are very receptive to metastatic action. Long bone survey may be done in conjunction with matastic survey.

4-30. LONG BONE SERIES

This examination is usually done for the purpose of diagnosing malformations of long bones caused by disease, a retardation of bone growth, or a stoppage of the normal bone growth process. The patient will usually exhibit various symptoms such as curvature of the extremities (bowlegs, knock-knee, etc.) or a shortening of one of the extremities. When shortening does occur, differentiation can be established as to whether the shortening is functional or anatomical. This is accomplished by measurements of both related extremities to determine actual figures. An anatomically short extremity will show a shorter measurement of the bones than the other. Conversely, a functionally short extremity, usually due to occupation or bad posture, will have the same bone measurement as the other comparative extremity. The shortening in the latter case is due to the carrying angle of the body. A long bone series, then, is a comparative study in which both related extremities are examined. Suggested routine: AP only, bilateral, full-length humerus, distal femurs, legs, and AP pelvis.

4-31. BONE AGE

Normally, the body follows an average bone pattern with regard to ossification of certain areas at specific time intervals. Any gross deviation from this average is considered abnormal and may be the means by which certain pathologies are diagnosed. Ideally, radiographic of the entire skeleton would be studied before the skeletal age is estimated. In daily clinical practice, however, the time-consuming, expensive radiographic examination of all of the bones cannot be carried out except in special cases. For this reason, a small and convenient portion of the skeleton, commonly the wrist and hand, is considered representative of the entire skeleton in the

assessment of bone age; however, during the first months of life, the feet are more satisfactory for appraisal of bone age because more ossification centers appear at an earlier age than in the hand. Associated radiographic views will be governed by the established routine of various clinics. The procedure is always such that comparative views of two similar areas are taken, that is, both hands, both feet, both forearms, etc.

4-32. SCANOGRAPHY

a. Scanography is a radiographic procedure that provides an accurate measurement of long bones. It consists of taking radiographs of the joints of long bones using a special metal ruler taped to the table. This examination is done quite frequently on children if the physical findings suggest a difference in the length of their extremities. It may also be used to determine the length of the femur before the insertion of an intermedullary pin in surgery. The method generally used is spot scanography.

b. In addition to the standard x-ray unit, a special radiopaque rule is needed to accomplish the examination. The positions in this examination are standard AP positions of the lower extremities. We will discuss both the use of the ruler and the importance of the proper position.

4-33. SPOT SCANOGRAPHY

In spot scanography, two “spot” exposures are made at specific points on the part. The film-object plane is parallel and CR is perpendicular to the film plane. The part and film remain in the same position during both exposures. The film identification is “burned-in” after completion of spot exposures. If the part under consideration is of such length that it overrides the film, the film may be placed diagonally with the long axis of the part. Measurements are made after the film is processed.

4-34. PRINCIPLES OF SCANOGRAPHY

The radiopaque ruler is a specially constructed ruler. It is evenly graduated, usually at 1-cm intervals, up to 100 cm. This is a sufficient length to include the long bones of the lower extremities. Its purpose is to show the magnification of the part in relation to the ruler. A perpendicular central ray is used to reduce the magnification caused by divergence of the beam. This provides for an accurate measurement. The central ray must be restricted to the area of interest; this requires proper collimation.

4-35. PROCEDURES

Place the ruler on the midline of the table and tape it there so that it cannot move. Position the patient over the ruler and in the supine position with the medial plane centered to the table and the ruler. You will concern yourself with three joints of the lower extremities and make three exposures on one masked film. With this in mind, position the level of the hip to the uppermost part of the ruler. True positions of the lower extremities are essential. Therefore, if there is any rotation of a part, true measurement will not be possible. Both extremities are x-rayed for comparison. The first exposure is made of both hips and is properly collimated to a 14 by 5-inch field. This will include both hips on the upper part of the film. After the first exposure, without moving patient or ruler, center the central ray to a point midway to the apex of the patella. Center the middle portion of the film to that point and make the second exposure. Center the third exposure to a point midway between the malleoli of the ankles with the bottom portion of the cassette centered to that point. This will give you a radiograph of hips, knees, and ankles, along with the ruler, on the same film. The exact length of the bone can then be determined by measuring from joint to joint.

4-36. SCOLIOSIS

If the spine is viewed from the posterior or anterior perspective, the vertebral column is usually nearly straight with little lateral curvature. Occasionally, a slight lateral curvature occurs in the upper thoracic region of a healthy adult. This curvature is usually associated with the dominant extremity; this curvature may be convex to the right in a right-handed person and convex to the left in a left-handed person. An abnormal or exaggerated lateral curvature is called scoliosis (sko”le-o ‘sis). This is a more serious type of problem that occurs when a pronounced S-shaped lateral curvature exists. This may cause severe deformity of the entire thorax. The effect of scoliosis is more obvious if it occurs in the lower vertebral column where it may create a tilting of the pelvis with a resulting effect on the lower limbs, thus creating a limp or uneven walk. Although many individuals normally have some slight lateral curvature of the thoracic spine, an abnormal or exaggerated lateral curvature of the spine is scoliosis. Scoliosis is most common in children 10 to 14; it is more common in girls. It may require wearing a back brace for a period of time until the condition of vertebral stability improves.

a. **Radiographic Examination.**

(1) Radiographs are made as requested by the patient's physician. The routine radiographs are PA or AP (posterior-anterior or anterior-posterior) projections and the lateral position. The patient may be positioned either erect or recumbent. The weight must be evenly distributed on both feet if the patient is erect.

(a) Structures shown: The lumbar and thoracic vertebrae, as well as the approximately 2 inches (5cm) of the iliac crests.

(b) Position: Thoracic and lumbar vertebrae are demonstrated in as true AP and lateral projections as possible. Some rotation of pelvis and/or thorax may be apparent because scoliosis generally is accompanied by a twisting or rotation of involved vertebrae.

(c) Collimation and CR: Vertebral column should be in center of collimation field/IR (image receptor).

(d) Shielding: Shield gonadal region without obscuring area of interest. Use breast shields for young females. Shadow shields placed on collimator may be used. See figure 4-9.

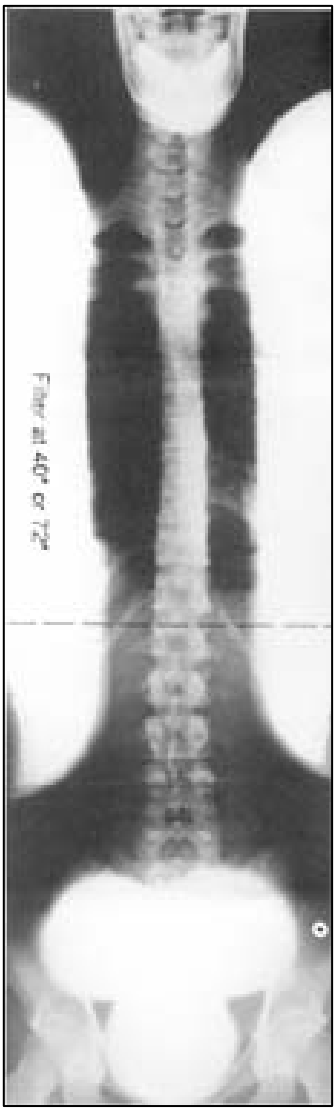


Figure 4-9. AP projection.

(2) The Clear Lead Compensating Filter System protects the patient and reduces exposure to breasts and gonadal areas. It is used at 40 inches or 70 inches. It is magnetic and is quick and easy to use. Clear Lead avoids graininess of aluminum filters and eliminates burn areas. See figure 4-10.

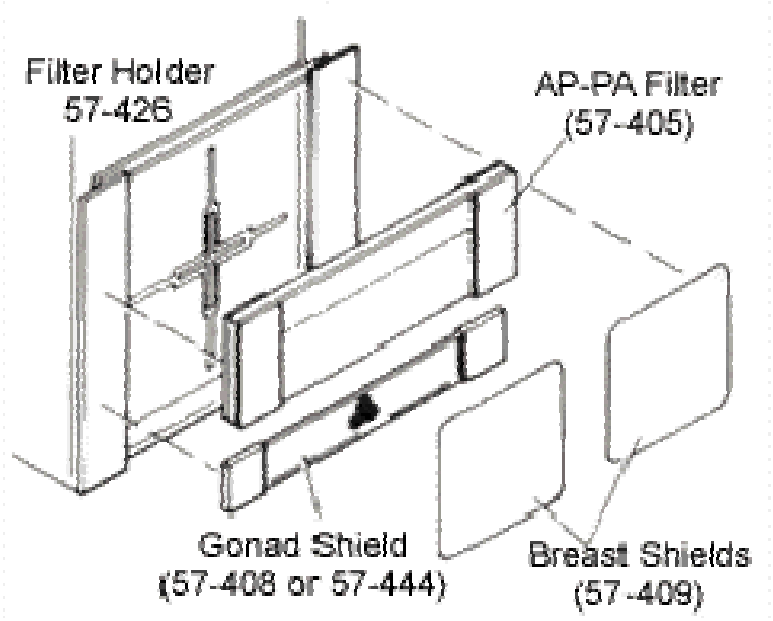


Figure 4-10. Compensating filters.

(3) Alternate series: Include different methods of demonstrating the effects of the curvature. In addition to the AP and PA views, left and right lateral-bending and hyperextension-hyperflexion series are sometimes done to demonstrate the actual range of motion to compare to degree of curvature.

(4) Measurement of scoliosis: There are two accepted methods of measurement--the Cobb and Ferguson methods of scoliosis measurement.

(a) Cobb's method is the standard method of measurement. It is primarily used for curvatures over 50 degrees.

(b) Ferguson method involves obtaining two images, one standard erect AP and PA and one with the foot or hip on the convex side of the curve elevated. It is primarily used for curvatures under 50 degrees.

b. **Treatment.** Treatment of scoliosis varies with the severity and involves the use of braces and, in the severest cases, surgical insertion of spinal fixation devices. The prototypical spinal fixation device is the venerable Harrington rod (figure 4-11). They come in two types: distraction and compression. The hooks, by design, are placed under the lamina or transverse processes and the device is either extended or compressed to the desired position. Sometimes both types of rods will be used in the same spine.

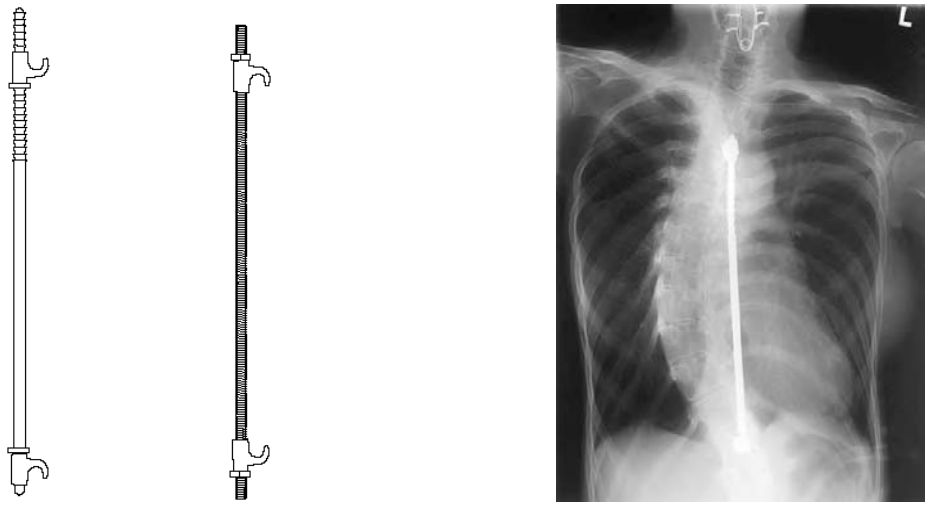


Figure 4-11: Harrington rods: Diagram on left, radiographic on right.

Section VI. RADIOGRAPHIC DEMONSTRATION OF FLUID LEVELS

4-37. INTRODUCTION

The collection, dispersion, shifting, or superimposition of free fluid with contiguous or ambient structures within the body cavities often requires a special technique for adequate diagnostic demonstration, such as differentiation between free fluid and thickened membranes or determination of the amount and behavior of free fluid within a body cavity. The procedure by which this is accomplished is known as fluid-level radiograph. The regions most commonly examined are the paranasal sinuses, the interpleural spaces, and the abdominal cavity.

4-38. PRINCIPLES

a. There is one prime requisite that must remain constant at all times when performing fluid-level radiography--the CR (or projection) must always be horizontal. Also, as nearly as circumstances permit, the horizontal CR should be parallel with, and at the same elevation as, the plane of the fluid level.

(1) Figure 4-12, part A, shows the horizontal CR at the same elevation as the plane of the fluid level. This demonstrates the plane of the fluid level with clear demarcation.

(2) Figure 4-12, part B, shows the effect of aligning the horizontal CR at a lower elevation in relation to the fluid level, the actual projection being accomplished by vertical divergent rays origination from the same source-point as the horizontal CR. The resultant image demonstrates a distorted and diffused outline of the fluid level which, in some cases, may be of doubtful diagnostic value.

(3) Figure 4-12, part C, shows the same object projected by a vertical CR. This illustrates a violation of the basic rule with respect to the constant horizontal CR. In a strict sense, no fluid level as such is demonstrated by the use of a vertical CR. Projections of this nature are sometimes used; however, to supplement regular fluid-level projections for purposes of comparison with previous or subsequent radiographs or to demonstrate certain aspects pertaining to the collection, dispersion, or characteristic behavior of free fluid.

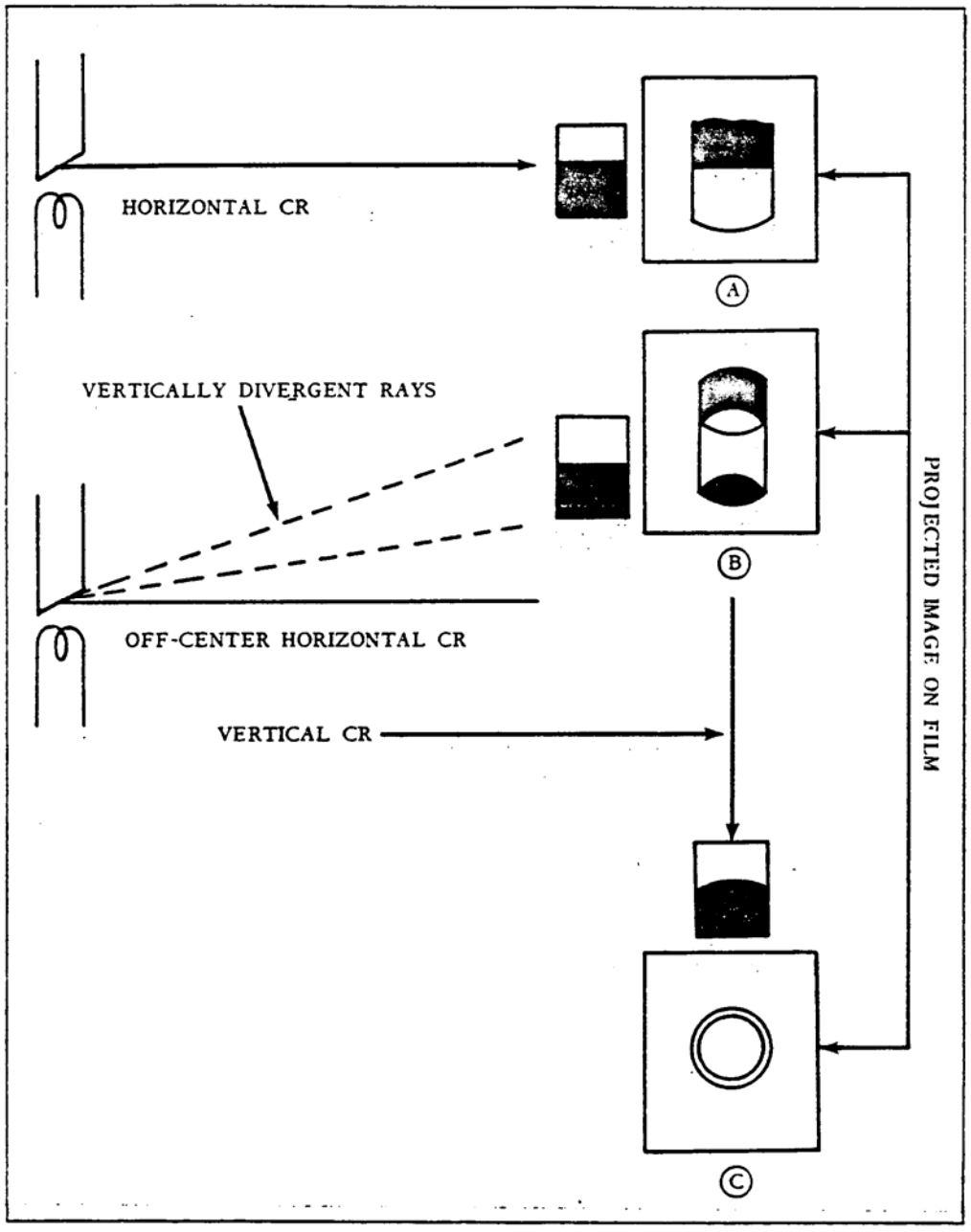


Figure 4-12. Schematic representation of fluid-level radiography with a drinking glass partially filled with barium sulfate suspension demonstrated in steps A, B and C.

b. When it is necessary or desirable to demonstrate multiple fluid levels (situated at different elevations in relation to the horizontal CR) on a single radiograph (for example, the abdominal region), increasing the SID will tend to obviate some of the adverse effects of "off-center" projection.

c. In general, the behavior of free fluid is demonstrated radiographically in figures 4-13 (exposed with CR in vertical position) and 4-14 (exposed with CR in horizontal position). Notice in figure 4-13, there is no evidence of the disposition of fluid, while in figure 4-14; the fluid is in well-defined levels.

Figure 4-13. Projection of abdomen made with the central ray in the vertical relationship and the patient in the supine position. This view shows no definite evidence of the disposition of fluid.

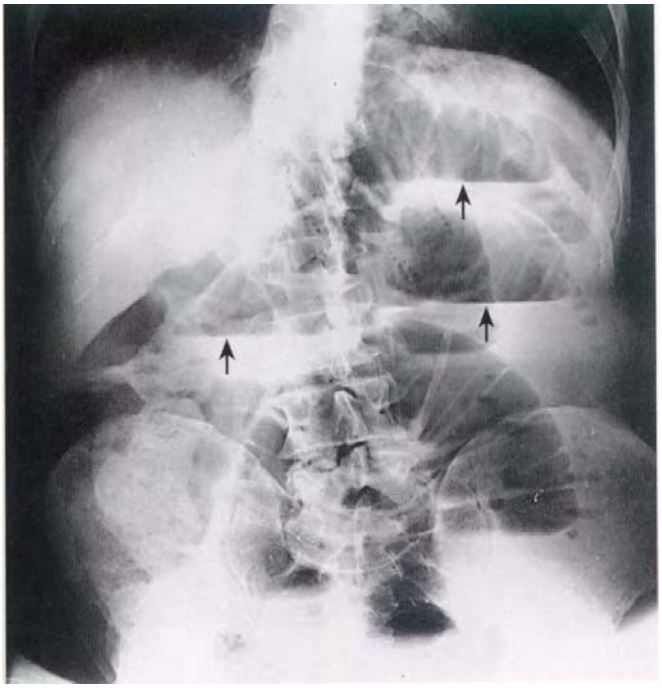


Figure 4-14. Projection of abdomen made with the central ray in the horizontal relationship and the patient in the erect position. Note disposition of fluid into well-defined levels.

4-39 CLINICAL PROCEDURE

a. After the patient has been placed in the position in which the radiograph is to be made, it is generally advisable to allow an elapse of 2 to 4 minutes before making the exposure. This interval permits gravitation or "settling" of the free fluid

b. Fluid-level radiography can be performed with the patient in the erect, supine, prone, or lateral decubitus position or with the patient placed in various inclined-plane positions, depending upon clinical desires or dictates (figures 4-15 and 4-16).

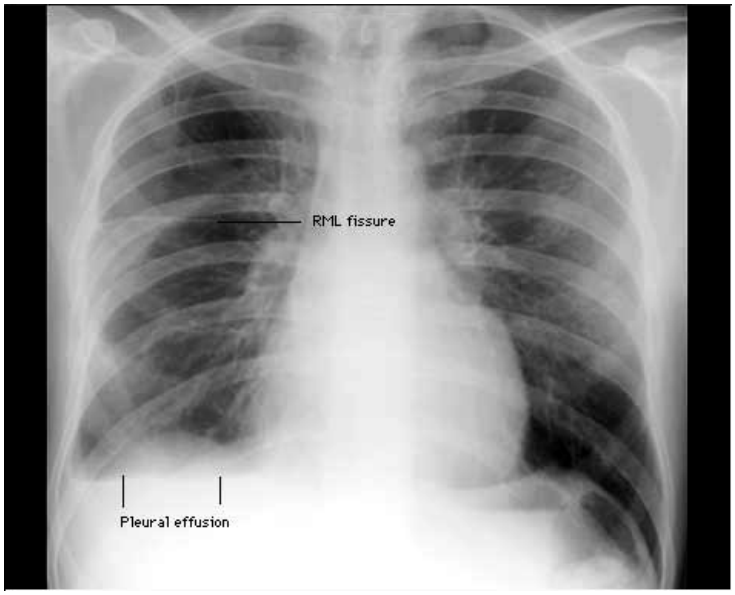


Figure 4-15. Demonstration of fluid level in the chest cavity with the patient in the erect position and the central ray projected in the horizontal direction.

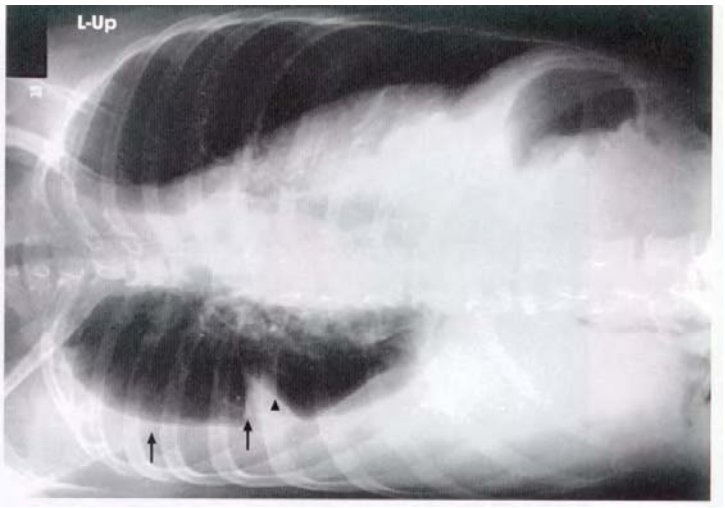


Figure 4-16. Demonstration of fluid level accomplished with the patient in the lateral decubitus position and the central ray projected in the horizontal direction.

c. Oftentimes, in order to accomplish fluid-level studies of a special kind, it is necessary to introduce a contrast medium (for example, Lipiodol or a similar substance) into the body cavities under investigation.

CAUTION: When executing injected sinus procedures, care should be taken to see that the injected substance is not expelled. In case the patient reports to the x-ray department with the contrast medium already injected, exposure should be made immediately upon his arrival, if possible.

Section VII. SOFT TISSUE RADIOLOGY

4-40. INTRODUCTION

Soft-tissue radiography is a procedure whereby the associated technical factors are so balanced as to produce a radiograph that provides optimum demonstration of the essential details within the soft-tissue structure under consideration. Since a radiograph of any part of the body is a study of the differences in density within the area exposed, a practical knowledge of the related technical factors influencing the range or magnitude of these differences in density is very useful in accomplishing soft-tissue radiography. Many factors that influence radiographic quality have already been considered in detail in another subcourse. When applied to soft-tissue radiography, some differences of emphasis among the various factors become necessary, depending upon the part or parts of interest. The principal aim is to achieve maximum contrast based on the differences in density of the tissues in question. Some parts of the body lend themselves more readily to this procedure than others. Anatomical parts or areas having great differences in tissue density are less difficult and allow for wider latitude in exposure factors. On the other hand, when a body of soft tissue consists of adjacent-lying structures with each differing in density to an extent approaching imperceptibility, it is necessary to employ the most exacting technique if maximum diagnostic quality is to be obtained.

4-41. USES

Some of the situations and conditions wherein soft-tissue radiography techniques may be needed are listed below.

a. **Muscles.** You may be required to perform work showing anatomic outlines of specific muscle structures, areas of calcification, ruptures, or areas of muscular ossification.

b. **Blood Vessels.** Radiographs demonstrating various forms of calcification, varicose veins, phleboliths, or thrombi may be needed.

c. **Breast.** You may make exposures to locate possible tumors of the breast.

d. **Tumors.** Radiographs that demonstrate the extent, location, and characteristics of various cartilaginous or nonosseous tumors may be required.

e. **Gas Gangrene.** You may be asked to do work demonstrating the presence and extent of involvement of gas gangrene.

f. **Foreign Bodies.** Various nonmetallic foreign bodies may need to be located.

g. **Fracture Sites.** Soft-tissue techniques are needed to demonstrate early callus development at fracture sites.

4-42. TECHNICAL FACTORS AND PROCEDURE

a. **General.** The vital principle of soft-tissue radiography is that full advantage is taken of all factors that contribute to the optimum differentiation of soft-tissue details.

(1) The technique must be selective. For a specific body of soft tissue to be x-rayed, all the associated technical variables should be "correct" for only that particular part under examination. The part or area of interest must be definitely circumscribed as to zone, extent, thickness, and density. It is impractical to attempt to combine structures of varying thickness and densities on the same radiograph with the part that is the focal point of diagnostic interest.

(2) The soft-tissue part must be adequately penetrated. The main objective is to produce differentiation of details within the soft-tissue structure and not merely the semblance of an outline. The practical kVp range is from 40 to 70, but each case must be judged on the thickness and density of the part. Use the lowest kVp necessary for adequate penetration.

(3) The radiograph should exhibit relatively high (short-scale) contrast graduated over the entire image pattern. The emphasis on short-scale contrast should be solely for the purpose of causing the finer image details to be demonstrated clearly. A radiograph presenting a chalky appearance, areas devoid of silver, or areas of excessively dense silver deposits is of little or no diagnostic value.

b. **Factors.** To obtain the quality of radiographic contrast suitable for soft-tissue radiography, the following factors must receive consideration.

(1) A relatively high mAs ratio with as low a kVp as is consistent with adequate penetration for the particular soft-tissue structure under examination should be used.

(2) Non-screen film in a cardboard holder is useful when referring to the detail factor and the exposure latitude involved. However, the use of intensifying screens aids in obtaining contrast and reduces the exposure time. The use of a cassette with a single screen (back) may prove especially advantageous at the very low kVp ranges where the front screen might absorb too much of the remnant radiation. In the majority of cases, however, satisfactory results can be obtained by the use of double screens.

(3) Best results are achieved when filtration of the primary x-ray beam is at a minimum, especially if the tissue thickness is very small.

(4) Beam-restricting devices are especially useful because they limit the amount of irradiation to the part, with consequent lessening of fogging SR.

(5) The processing of the exposed film is more critical than in conventional radiography. Time-temperature development in fresh solutions of proper strength is imperative. Safe lighting must conform to proper standards of darkroom illumination. The film emulsion must be fresh and have unimpaired quality.

c. **X-ray Unit.** A full-wave rectified x-ray unit of sufficient capacity and equipped with a rotating anode tube is preferred. With this type of unit, it is possible to minimize the effects of motion unsharpness by the use of shorter exposure times.

d. **Positioning.** Positioning of the part is the same as for routine radiography. Modification in positioning or in the alignment of the CR may be necessary to circumvent overlying bone or other structures that may obscure the site of interest.

e. **Basic Technique.** The basic technique factors given below (see table 4-2) should prove of value as a starting procedure and are listed solely for the guidance of the x-ray specialist. They are based on the average-sized adult using a full-wave rectified unit and par speed intensifying screens. If a trial exposure is indicated to determine the characteristic behavior of the x-ray unit or intensifying screens, a small portion of the site to be demonstrated should be selected and the surrounding areas marked off with suitable radiopaque materials prior to making the exposure. Examination of the test exposure should enable the x-ray specialist to make the necessary adjustments. If the exposed area on the film is excessively dense, the mAs (milliamperes-seconds) value should be reduced; if it is blank or devoid of image details, the kVp should be increased. The following techniques should prove useful as those suitable for average adult exposures.

PART	kVp	mAs	SID
Hand and wrist	52	2*	40"
Elbow and ankle	58	3*	40"
Humerus	65	4*	40"
Leg	62	3*	40"
Knee	66	5*/10	40"
Thigh	70	12	40"
Neck	70	12	40"
Neck, lateral	75	12	72"
* NG-Non-grid			

Table 4-2. Basic technical factors.

Section VIII. PORTABLE RADIOGRAPHY

4-43. INTRODUCTION

At times, it is necessary to perform radiographic examinations outside the radiology department. One common site for these examinations is in the patient's room on the ward (sometimes called nursing unit). He may be seriously ill, in isolation, in traction, or incapacitated in some other way that prevents him from coming to the department. Another place where portable equipment procedures are frequently accomplished is in the surgical suite. In this case, the examinations are performed in conjunction with surgical procedures. Two examples of this mechanical fixation are fractures and cholecystectomy.

4-44. PORTABLE X-RAY MACHINES

a. Portable x-rays units vary considerably from hospital to hospital. They differ in tube capacity, rectification, design, and so forth; therefore, this section will not attempt to describe any particular portable units. The x-ray specialist should become familiar with the unit in his department by studying the manufacturer's operational instructions. A portable x-ray machines are shown in figures 4-17 and 4-18.

b. Ensure all radiographic equipment use spark proof plugs to prevent explosions or fires. This safety precaution cannot be overemphasized because of the hazard that exists with flammable or explosive gases used in hospitals. Even a tiny spark is enough to cause an explosion that would be dangerous for the patient and operating room personnel. If there is any doubt as the reliability in this regard of the equipment to be used, discuss the situation with the anesthetist and the medical equipment repairmen. Do not assume the equipment is safe just because it has been used without incidence in the past.

4-45. RADIATION PROTECTION

a. **General.** The radiation hazard in portable radiography is potentially greater than the conventional exposure room in the radiology department. This hazard is greater because portable examinations are usually conducted in areas that have no protective barriers. For this reason, exposure to the x-ray specialist will be increased somewhat over exposures received in the department. The x-ray specialist can, however, keep exposure down to a minimum for himself, the patient, and others who are in the area by following a few simple rules. Most of these measures are not limited to portable equipment radiography, but should be practiced in the radiology department as well.

Figure 4-17: General Electric AMX 4, Portable radiographic equipment.

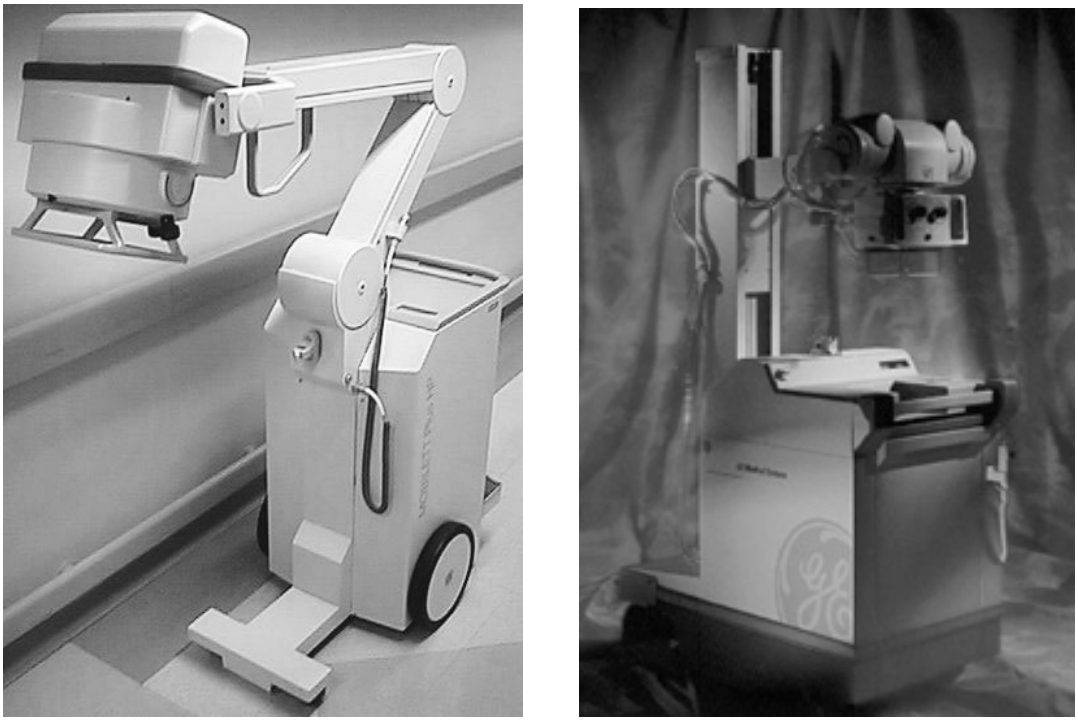


Figure 4-18. Modern portable x-ray machines.

b. **Standing Clear of the Primary Beam.** Because of the difficulty involved in positioning and immobilizing certain patients, you may be tempted to expedite an examination by holding the patient or film holder with one hand while making the exposure with the other. Do not engage in this practice! Use personnel who are not occupationally exposed to radiation to assist you in holding the patient and film holder in order to keep yourself clear of the primary beam. These assistants must wear lead aprons and gloves and stay out of the primary beam.

c. **Using the Inverse Square Law.** Always stand as far as possible from the tube and patient when making an exposure. By doing this, you will be taking advantage of the inverse square law. For example, if you stand 6 feet from the tube, your exposure would be about 25 percent of the amount you would receive standing 3 feet from the tube.

d. **Using Beam Restricting Devices.** If the portable unit is equipped with a collimating device, use it to restrict the primary beam to the size of the film. If no collimator is available, use a cone, cylinder, or diaphragm to reduce the primary beam to the film size. Restricting the primary beam is a protective aid. First, it reduces the amount of SR (secondary radiation and scatter radiation) by reducing the exposed areas that produce secondary radiation. In addition, it will reduce the primary radiation exposure to the patient. Radiographic detail will also be enhanced because of the reduction of film fog due to SR.

e. **Wearing Protective Devices.** The x-ray specialist should wear a lead apron when making the exposure. When worn properly, the apron will shield a major portion of the body from radiation. Ensure that personnel assisting you in holding the patient or film holder are also protected with lead aprons and gloves. As mentioned before, use only personnel not occupationally exposed to ionizing radiation. All others in the area not essential to the examination should be asked to leave until after the examination is completed.

f. **Wearing the Film Badge.** The importance of the film badge greatly increases when the x-ray specialist is using portable equipment, because the radiation hazard is increased. Be sure to wear it properly. The whole body film badge is worn beneath the lead apron on the outside of the basic clothing and below the shoulder and above the hips.

g. **Rotating Personnel.** When practical, it is advisable to rotate personnel operating portable equipment so that no one x-ray specialist operates the unit permanently or for extended periods. This policy is particularly important when a number of portable equipment examinations are performed day after day.

4-46. FILM HOLDERS AND GRIDS

a. **General.** The choice of film holders can play an important role in the quality of the finished radiograph made by portable examination. SR, as it affects film quality, must also be considered when examinations are not limited to small parts, the chest, or other areas where SR is not a problem.

b. **Film Holders.** As a general rule, portable equipment examinations should be done using screen technique. One reason for this is that minimum exposure times are possible when using intensifying screens. Since patients involved in these examinations are frequently not able to cooperate by remaining motionless, fast exposure times can be a valuable asset in improving the clarity of the radiograph. Another reason cassettes are advantageous is mAs required for non-screen exposures might exceed the capacity of the unit. Finally, cassettes can better withstand the weight involved in some portable equipment examination.

c. **Grids.** Grids (either portable or grid cassettes) should be used for all examinations where SR might pose a problem. An unfocused grid is recommended for general use because you frequently are unable to use the SID required by a focused grid. This is not to say that a focused grid cannot be used. On the contrary, these will produce excellent results when you are able to determine the SID ahead of time and bring the proper grid. For general use, however, when the exact circumstances are not known beforehand, an unfocused or parallel grid should be used.

4-47. BEDSIDE RADIOGRAPHY

a. It is difficult to establish definite procedures for bedside examinations because of the unpredictable conditions of patients. A procedure that works perfectly for one patient may not work for another. Therefore, the x-ray specialist must decide upon the best course of action depending on the circumstances. Some common sense rules, however, will apply in most cases.

b. It is good practice, when the patient's condition permits, to go into the room and introduce yourself to the patient before bringing in the portable unit. At this time, ensure you have the correct patient by checking the armband or by checking with the nurses' station. The abrupt entrance of an x-ray specialist propelling a large, strange machine may alarm some patients unless they have been told to expect this.

c. If intravenous (IV) fluids are being administered, use care in preparing the patient and the bed for the examination. Rough handling of either may cause the needle to dislodge from the vein and the fluid to infiltrate the surrounding tissue. Be extra careful with other devices that may be in use--suction apparatus, traction device, and so forth.

d. If the patient is receiving oxygen, ensure you use care in preparing the patient and the bed for the examination. Do not disconnect the oxygen. If you need to remove an oxygen mask, obtain a nurse's permission before removing the mask. If possible, have the nurse turn off the oxygen and remove the mask. While oxygen alone does not burn, it most certainly supports combustion.

e. When positioning the patient, make modifications in accordance with his condition and the limitations of the portable unit. For example, to project a lateral knee on a patient who cannot rotate the leg into the ordinary position, raise the knee slightly and support it with a pillow; then place the cassette on edge and align the tube from a horizontal position.

f. When a bedside examination is accomplished on a patient in isolation, the portable unit and all accessory equipment must be cleaned afterwards. The ward will provide the solution, a hospital-approved disinfectant.

4-48. SURGICAL RADIOGRAPHY

a. **General.** On occasion, radiographic procedures are part of a surgical routine. Such surgical procedures as cholecystectomy (removal of the gall bladder) or the reduction and/or mechanical fixation of a fracture usually require radiographic support. In such cases, the radiographic examinations are conducted in the operating room under sterile conditions.

b. **Location of Power Source.** The power source in the operating room is located between 4 and 4 1/2 feet above floor level to provide an added safety factor. The anesthetic gases are heavier than air and, in case of leakage, settle to the floor. An electrical spark at floor level, as would be the case with conventionally placed floor-level receptacles, could produce a devastating explosion or fire.

c. **Surgical Attire.** When working in the operating room, the x-ray specialist must be clean and as free from bacteria as possible, short of sterilization. Consequently, he changes into surgical clothes, which consist of shirt, trousers, cap, mask, and conductive boots. Female attire consists of a one-piece cotton dress that snaps up the back and is belted by cotton ties. Since one purpose of the cotton dress is to prevent the build-up of static electricity, nylon undergarments are not worn.

d. **Cleaning the Machine.** The portable unit must be cleaned before it is taken into the operating room. This cleaning consists of washing it down with an antiseptic agent. Wescodyne or 70 percent isopropyl alcohol may be used. When washing the unit, give special attention to the tube housing, the accessory devices on the tube housing, and to the tube arm. These portions of the machine will be over the sterile field, so they must be completely clean.

e. **Performing the Examination.** As with bedside radiography, it is difficult to establish set procedures for radiographic work in surgery. Different surgeons require different projections, variation in numbers of film, and so forth. The requirements also vary with identical examinations, depending upon the suspected pathology. The x-ray specialist, therefore, must vary his procedure according to the desires of the surgeon. Some of the following principles will apply in certain cases.

(1) Offer lead aprons to all members of the surgical team. If the team member must work under sterile conditions, it will be necessary for him to remove his apron before putting on the sterile gown. Some members of the team may not want a protective apron, but each person should be offered one.

(2) Make a scout film whenever possible. This will help to ensure that the patient is properly positioned and that the exposure factors are correct.

(3) Coordinate the exposure with the anesthetist. Remember, he controls the patient's breathing, so he must stop the breathing before the exposure.

(4) Process the films as quickly as possible and return them to the surgeon.

Continue with Exercises

EXERCISES, LESSON 4

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the question or best completes the incomplete statement.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers. For each exercise answered incorrectly, reread the material referenced with the solution.

1. The virginal breast consists primarily of _____ tissue.

   a. Fatty.

   b. Muscular.

   c. Fibroglandular.

   d. Calculus.

2. One of the important factors to consider in mammography is focal spot size. If the large focal spot is used, it may adversely affect detail; but if the small one is used:

   a. The exposure factors must be low enough.

   b. Penetration of the rays may be too low.

   c. More irradiation damage may result.

   d. The radiograph may lack density.

3. For a mammography study, if the kVp is 25 and the mAs 1600, three views would generate _____HU.

   a. 40,000.

   b. 80,000.

   c. 120,000.

   d. 240,000.

4. For voltages under 50 kVp, the minimum filtration equivalent is:

   a. 0.3 mm aluminum equivalent.

   b. 0.5 mm aluminum equivalent.

   c. 1.0 mm aluminum equivalent.

   d. 1.5 mm aluminum equivalent.

5. Frequently, the larger breast will require less technique rather than more. This is because the larger breast:

   a. Is more muscular.

   b. Has more glands.

   c. Often has more fatty tissue and lies flatter.

   d. Is more dense.

6. In the craniocaudad breast position, the patient is to put her hand behind her back and:

   a. Sit up straight.

   b. Lean to one side.

   c. Cough.

   d. Bend slightly backward.

7. For a mediolateral breast projection, the patient is in what position?

   a. Laterally recumbent.

   b. Prone.

   c. Erect.

   d. Supine.

8. The greatest problem the x-ray specialist has in producing acceptable radiographs of infants and children is the:

    a. Indifference of parents.

    b. Interference of parents.

    c. Adverse effects of motion.

    d. Unpredictable absorption qualities inherent to children.

9. In gastrointestinal examinations of infants, how should the contrast medium be administered?

    a. Spoon.

    b. Nursing bottle.

    c. Syringe.

    d. Eyedropper.

10. Tomography depends upon:

    a. Focusing x-rays.

    b. Blurring out unwanted structures.

    c. OFD.

    d. SID.

11. Where there is a choice of the type of tube and film movement, which of the following would be used in tomography of the skull?

    a. Rectilinear.

    b. Circular.

    c. Elliptical.

    d. Hypocycloidal.

12. Amplitude affects the thickness of the section demonstrated on a tomogram. Another factor that controls thickness is:

a. OFD.

b. mAs.

c. SID.

d. kVp.

13. Because tube movement has the effect of increasing part thickness, an increase of _____ in mAs over the normal technique for the part is needed for tomography.

a. 50 to 75 percent.

b. 50 to 100 percent.

c. 75 to 150 percent.

d. 100 to 150 percent.

14. A particular body section unit is set for a tube amplitude of 24 inches and a rate of 12 inches per second. What exposure time (in seconds) should be set?

a. 0.5.

b. 1.5.

c. 2.0.

d. 2.5.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 4

1. c (para 4-2c(1))
2. a (para 4-3)
3. d (para 4-4) (1600 x 25 x 3 x 2)
4. b (para 4-5)
5. c (para 4-8f)
6. d (para 4-9a(6))
7. a (para 4-9b(1))
8. c (para 4-13c)
9. b (para 4-14e(1))
10. b (para 4-15b)
11. d (para 4-16b(3))
12. c (para 4-18)
13. b (para 4-19)
14. c (para 4-20a)

End of Lesson 4